PROCEEDINGS

OF

THE AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE,

THIRTY-SIXTH MEETING,

HELD AT

NEW YORK,

AUGUST, 1887.

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HENRY WHEATLAND of Salem,
THOMAS MEEHAN of Germantown.

MEETINGS AND OFFICERS OF THE AMERICAN ASSOCIATION OF GEOLOGISTS AND NATURALISTS.

MEETING.	DATE.	PLACE.	CHAIRMAN.	SECRETARY.	ASSIS'T SEC'Y.	TREASURER.
1st	April 2, 1840,	Philadelphia,	Edward Hitchcock,*	L. C. Beck,*		
2d	April 5, 1841,	Philadelphia,	Benjamin Silliman,*	L. C. Beck,*	B. Silliman, jr.,* C. B. Trego,*	
3d	April 25, 1842,	Boston,	S. G. Morton,*	C. T. Jackson,*	J. D. Whitney, M. B. Williams,*	
4th	April 26, 1843,	Albany,	Henry D. Rogers,*	B. Silliman, jr.,*		John Locke.*
5th	May 8, 1844,	Washington,	John Locke,*	B. Silliman, jr.,* O. P. Hubbard,		Douglas Houghton.*
6th	April 30, 1845,	New Haven,	Wm. B. Rogers,*	B. Silliman, jr.,* J. Lawrence Smith,*		Douglas Houghton.*
7th	Sept. 2, 1846,	New York,	C. T. Jackson,*	B. Silliman, jr.,*		E. C. Herrick.*
8th	Sept. 20, 1847,	Boston,	Wm. B. Rogers,†*	Jeffries Wyman,*		B. Silliman, jr.*

* Deceased.

† Professor ROGERS, as chairman of this last meeting, called the first meeting of the new Association to order and presided until it was fully organized by the adoption of a constitution. As he was thus the first presiding officer of the new Association, it was directed at the Hartford meeting that his name be placed at the head of the Past Presidents of the American Association for the Advancement of Science.

MEETINGS AND OFFICERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE-PRESIDENT.	GENERAL SECRETARY.	PERMANENT SEC'Y.	TREASURER.
1st	Sept. 20, 1848,	Philadelphia, Pa.,	W. C. Redfield,*		Walter R. Johnson,*		Jeffries Wyman.*
2d	Aug. 14, 1849,	Cambridge, Mass.,	Joseph Henry,*		E. N. Horsford, 1		A. L. Elwyn.*
3d	Mar. 12, 1850,	Charleston, S. C.,	A. D. Bache,* 2		L. R. Gibbs, 3		St. J. Ravenel.* 4
4th	Aug. 19, 1850,	New Haven, Conn.,	A. D. Bache,*		E. C. Herrick,*		A. L. Elwyn.*
5th	May 5, 1851,	Cincinnati, Ohio,	A. D. Bache,*		W. B. Rogers, 5*	S. F. Baird,*	S. F. Baird. 6
6th	Aug. 19, 1851,	Albany, N. Y.,	Louis Agassiz,*		W. B. Rogers,*	S. F. Baird,*	A. L. Elwyn.*
7th	July 28, 1853,	Cleveland, Ohio,	Benjamin Pierce,*		S. St. John,* 7	S. F. Baird,*	A. L. Elwyn.*
8th	April 26, 1854,	Washington, D. C.,	J. D. Dana,		J. Lawrence Smith,*	Joseph Lovering,	J. L. LeConte* 8
9th	Aug. 15, 1855,	Providence, R. I.,	John Torrey,*		Wolcott Gibbs,	Joseph Lovering,	A. L. Elwyn.*
10th	Aug. 20, 1856,	Albany, N. Y.,	James Hall,		B. A. Gould,	Joseph Lovering,	A. L. Elwyn.*
11th	Aug. 12, 1857,	Montreal, Canada,	Alexis Caswell,* 9	Alexis Caswell,*	John LeConte,	Joseph Lovering,	A. L. Elwyn.*
12th	April 28, 1858,	Baltimore, Md.,	Alexis Caswell,* 10	John E. Holbrook,*†	W. M. Gillespie,* 11	Joseph Lovering,	A. L. Elwyn.*
13th	Aug. 3, 1859,	Springfield, Mass.,	Stephen Alexander,*	Edward Hitchcock,*	William Chauvenet,*	Joseph Lovering,	A. L. Elwyn.*
14th	Aug. 1, 1860,	Newport, R. I.,	Isaac Lea,*	B. A. Gould,	Joseph LeConte,	Joseph Lovering,	A. L. Elwyn.*
15th	Aug. 15, 1866,	Buffalo, N. Y.,	F. A. P. Barnard,	A. A. Gould,* 12	Elias Loomis, 13	Joseph Lovering,	A. L. Elwyn.†*
16th	Aug. 21, 1867,	Burlington, Vt.,	J. S. Newberry,	Wolcott Gibbs,	C. S. Lyman,	Joseph Lovering,	A. L. Elwyn.†*
17th	Aug. 5, 1868,	Chicago, Ill.,	B. A. Gould,	Charles Whittlesey,*	Simon Newcomb, 14	Joseph Lovering,	A. L. Elwyn.†*
18th	Aug. 18, 1869,	Salem, Mass.,	J. W. Foster,*	O. N. Rood,	O. C. Marsh,	F. W. Putnam, 15	A. L. Elwyn.†*
19th	Aug. 17, 1870,	Troy, N. Y.,	T. S. Hunt, 16	T. S. Hunt,	F. W. Putnam, 17	Joseph Lovering,	A. L. Elwyn.†*
20th	Aug. 16, 1871,	Indianapolis, Ind.,	Asa Gray,	G. F. Barker,	F. W. Putnam,	Joseph Lovering,	W. S. Vaux.*
21st	Aug. 15, 1872,	Dubuque, Iowa,	J. Lawrence Smith,*	Alex. Winchell,	E. S. Morse,	Joseph Lovering,	W. S. Vaux.*
22d	Aug. 20, 1873,	Portland, Me.,	Joseph Lovering,	A. H. Worthen,†	C. A. White,	F. W. Putnam,	W. S. Vaux.*
23d	Aug. 12, 1874,	Hartford, Conn.,	J. L. LeConte,*	C. S. Lyman,	A. C. Hamlin,	F. W. Putnam,	W. S. Vaux.†*

1. In place of Jeffries Wyman, *not present.*
2. In place of Joseph Henry, *not present.*
3. In place of E. C. Herrick, *not present.*
4. In place of A. L. Elwyn, *not present.*
5. In place of E. C. Herrick, *not present.*
6. In place of A. L. Elwyn, *not present.*
7. In place of J. D. Dana, *not present.*
8. In place of A. L. Elwyn, *not present.*
9. In place of J. W. Bailey, *deceased.*
10. In place of Jeffries Wyman, *not present.*
11. In place of Wm. Chauvenet, *not present.*
12. In place of R. W. Gibbes, *not present.*
13. In place of W. P. Trowbridge, *not present.*
14. In place of A. P. Rockwell, *called home 1st day.*
15. In place of Joseph Lovering, *in Europe.*
16. In place of Wm. Chauvenet, *too ill to be present.*
17. In place of C. F. Hartt, *in Brazil.*

* Deceased. † Not present at the meeting.

MEETINGS AND OFFICERS OF THE ASSOCIATION (*Continued*).

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENT, SECTION A.	VICE PRESIDENT, SECTION B.	CHAIRMAN OF PERMANENT SUBSECTION OF CHEMISTRY.	CHAIRMAN OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	CHAIRMAN OF PERMANENT SUBSECTION OF MICROSCOPY.	CHAIRMAN OF PERMANENT SUBSECTION OF ENTOMOLOGY.
24th	Aug. 11, 1875.	Detroit, Mich.,	J. E. Hilgard,	H. A. Newton,	J. W. Dawson,	S. W. Johnson,	L. H. Morgan,*	—	—
25th	Aug. 23, 1876.	Buffalo, N. Y.,	W. B. Rogers,*	C. A. Young,	E. S. Morse,	G. F. Barker,	L. H. Morgan,*	R. H. Ward,	—
26th	Aug. 29, 1877.	Nashville, Tenn.,	S. Newcomb,	R. H. Thurston,[1]	O. C. Marsh,	N. T. Lupton,	Daniel Wilson,†	R. H. Ward,	—
27th	Aug. 21, 1878.	St. Louis, Mo.,	O. C. Marsh,	R. H. Thurston,	Aug. R. Grote,	F. W. Clarke,	—[2]	R. H. Ward,[3]	—
28th	Aug. 27, 1879.	Saratoga, N. Y.,	G. F. Barker,	S. P. Langley,	J. W. Powell,	F. W. Clarke,[4]	Daniel Wilson,	E. W. Morley,	—
29th	Aug. 25, 1880.	Boston, Mass.,	L. H. Morgan,*	Asaph Hall,	Alex. Agassiz,	J. M. Ordway,	J. W. Powell,	S. A. Lattimore,	—
30th	Aug. 17, 1881.	Cincinnati, Ohio,	G. J. Brush,	Wm. Harkness,[7]	E. T. Cox,[8]	G. C. Caldwell,[9]	G. Mallery,	A. B. Hervey,	J. G. Morris.

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF SECTION A.	SECRETARY OF SECTION B.	SECRETARY OF PERMANENT SUBSECTION OF CHEMISTRY.	SECRETARY OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	SECRETARY OF PERMANENT SUBSECTION OF MICROSCOPY.	SECRETARY OF PERMANENT SUBSECTION OF ENTOMOLOGY.	TREASURER.
F. W. Putnam,	S. H. Scudder,	S. P. Langley, T. C. Mendenhall,	E. S. Morse,	F. W. Clarke,	F. W. Putnam,	—	—	W. S. Vaux.*
F. W. Putnam,	T. C. Mendenhall,	A. W. Wright,	Albert H. Tuttle,	H. C. Bolton,	O. T. Mason,	E. W. Morley,	—	W. S. Vaux.*
F. W. Putnam,	Aug. R. Grote,	H. C. Bolton,	Wm. H. Dall,	P. Schweitzer,	—[2]	T. O. Summers, jr.,	—	W. S. Vaux.†*
F. W. Putnam,	H. C. Bolton,	F. E. Nipher,	George Little,	A. P. S. Stuart,	—[2]	G. J. Engelmann,	—	W. S. Vaux.†*
F. W. Putnam,	H. C. Bolton,[5]	J. K. Rees,	W. H. Dall,[6]	W. R. Nichols,*	J. G. Henderson,	A. B. Hervey,	—	W. S. Vaux.†*
F. W. Putnam,	J. K. Rees,	H. B. Mason,	C. V. Riley,	C. E. Munroe,	J. G. Henderson,	A. B. Hervey,	—	W. S. Vaux.*
F. W. Putnam,	C. V. Riley,	E. T. Tappan,[10]	Wm. Saunders,	A. Springer,[12]	J. G. Henderson,	W. H. Seaman,[11]	B. P. Mann,	W. S. Vaux.†*

[1] In the absence of E. C. Pickering.
[2] The Subsection united with Sec. B.
[3] In the absence of G. S. Blackie.
[4] In the absence of Ira Remsen.
[5] In the absence of George Little.
[6] In the absence of A. C. Wetherby.
[7] In the absence of A. M. Mayer.
[8] In the absence of George Engelmann.
[9] In the absence of W. R. Nichols.
[10] In the absence of John Trowbridge.
[11] In the absence of S. P. Sharples.
[12] In place of H. W. Wiley, called away.
* Deceased.
† Not present.

MEETINGS AND OFFICERS OF THE ASSOCIATION. (*Continued.*)

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENTS.				
				Section A.	Section B.	Section C.	Section D.	Section E.
31st	Aug. 23, 1882.	Montreal, Can.	J. W. Dawson,	W. A. Rogers,[1]	T.C. Mendenhall,	H. C. Bolton,	W. P. Trowbridge,	E. T. Cox,
32nd	Aug. 15, 1883.	Minneapolis, M.	C. A. Young,	W. A. Rogers,	H. A. Rowland,	E. W. Morley,	De Volsen Wood,[7]	C.H. Hitchcock,
33rd	Sept. 3, 1884.	Philadelphia, Pa.	J. P. Lesley,	H. T. Eddy,	J. Trowbridge,	J. W. Langley,	R. H. Thurston,	N. H. Winchell,
34th	Aug. 26, 1885.	Ann Arbor, Mich.	H. A. Newton,	W. Harkness,[15]	S. P. Langley,[16]	N. T. Lupton,[17]	J. Burkitt Webb,	Edward Orton,
35th	Aug. 18, 1886.	Buffalo, N. Y.	E. S. Morse,	J. W. Gibbs,	C. F. Brackett,	H. W. Wiley,	O. Chanute,	T. C. Chamberlin,
36th	Aug. 10, 1887.	New York,	S. P. Langley,	J. R. Eastman,[26]	W. A. Anthony,	A. B. Prescott	E. B. Coxe,	G. K. Gilbert,

VICE PRESIDENTS.				Permanent Secretary.	General Secretary.	Assistant Gen. Secretary.	SECRETARIES OF SECTION	
Section F.	Section G.	Section H.	Section I.				Section A.	Section B.
W. H. Dall,	A. H. Tuttle,	Alex. Winchell,[2]	E. B. Elliott,	F. W. Putnam,	Wm. Saunders,	J. R. Eastman,	H. T. Eddy,	C. S. Hastings,
W. J. Beal,	J. D. Cox,	O. T. Mason,	F. B. Hough,*	F. W. Putnam,	J. R. Eastman,	Alfred Springer,	G. W. Hough,[6]	F. E. Nipher,[9]
E. D. Cope.	T. G. Wormley,	E. S. Morse,	John Eaton,	F. W. Putnam,	Alfred Springer,	C. S. Minot,[12]	G. W. Hough,	N. D. C. Hodges,
T. J. Burrill,[18]	S. H. Gage,	J. O. Dorsey,[19]	Edw. Atkinson	F. W. Putnam,	C. S. Minot,	S. G. Williams,[20]	E. W. Hyde,	B. F. Thomas,[21]
H. P. Bowditch,	——[25]	H. Hale,	Jos. Cummings	F. W. Putnam,	S. G. Williams,	W. H. Pettee,	S. C. Chandler,	H. S. Carhart,
W. G. Farlow,	——	D. G. Brinton,	H. E. Alvord,	F. W. Putnam,	W. H. Pettee,	J. C. Arthur,	H. M. Paul,	C. Leo Mees,

SECRETARIES OF THE SECTIONS.							Treasurer.
Section C.	Section D.	Section E.	Section F.	Section G.	Section H.	Section I.	
Alfred Springer,	J. B. Webb,[3]	H. S. Williams,[4]	Wm. Osler,[5]	Robt. Brown, jr.,	O. T. Mason,	F. B. Hough,[6]*	——*
J. W. Langley,[10]	J. B. Webb,[11]	A. A. Julien,	S. A. Forbes,	Carl Seiler,	G. H. Perkins,	Jos. Cummings,	William Lilly.
H. Carmichael,[13]	J. B. Webb,	E. A. Smith,	C. E. Bessey,	R. Hitchcock,	G. H. Perkins,[14]	C. W. Smiley,	William Lilly.
F. P. Dunnington,	C. J. H. Woodbury,	G. K. Gilbert,[22]	J. A. Lintner,[23]	W. H. Walmsley,	Erm. A. Smith,*	C. W. Smiley,[24]	William Lilly.
W. McMurtrie,	William Kent,	E. W. Claypole,	J. C. Arthur,	——[25]	A. W. Butler,	H. E. Alvord,	William Lilly.
C. S. Mabery,[27]	G. M. Bond,	W. M. Davis,[28]	J. H. Comstock,	——	C. C. Abbott,[29]	W. R. Lazenby,	William Lilly.

1 In the absence of William Harkness.
2 In the absence of Daniel Wilson.
3 In the absence of C. B. Dudley.
4 In the absence of C. E. Dutton.
5 In the absence of C. S. Minot.
6 F. B. Hough was called home and J. R. Dodge acted at the close of the meeting.
7 Absent but place was not filled.
8 In the absence of W. W. Johnson.
9 In the absence of C. K. Wead.
10 W. M. McMurtrie, last three days of meeting.
11 Pro tempore.
12 In the absence of E. S. Holden.
13 In the absence of R. B. Warder.
14 In the absence of W. H. Holmes.
15 In the absence of J. M. Van Vleck.
16 In place of C. F. Brackett, resigned.
17 In the absence of W. R. Nichols.
18 In the absence of B. G. Wilder.
19 In the absence of W. H. Dall.
20 In place of C. C. Abbott, not present.
21 In place of A. A. Michelson, resigned.
22 In the absence of H. C. Lewis.
23 In place of C. H. Fernald, resigned.
24 In the absence of J. W. Chickering.
25 Section permanently united to Section F.
26 In place of W. Ferrel, resigned.
27 Absent; R. B. Warder acted as Sec'y pro tem.
28 In place of T. B. Comstock, absent.
29 In place of F. W. Langdon, absent.

*Deceased.

COMMONWEALTH OF MASSACHUSETTS.

IN THE YEAR ONE THOUSAND EIGHT HUNDRED AND SEVENTY-FOUR.

AN ACT

To Incorporate the "American Association for the Advancement of Science."

Be it enacted by the Senate and House of Representatives, in General Court assembled, and by the authority of the same, as follows:

Section 1. Joseph Henry of Washington, Benjamin Pierce of Cambridge, James D. Dana of New Haven, James Hall of Albany, Alexis Caswell of Providence, Stephen Alexander of Princeton, Isaac Lea of Philadelphia, F. A. P. Barnard of New York, John S. Newberry of Cleveland, B. A. Gould of Cambridge, T. Sterry Hunt of Boston, Asa Gray of Cambridge, J. Lawrence Smith of Louisville, Joseph Lovering of Cambridge and John LeConte of Philadelphia, their associates, the officers and members of the Association, known as the "American Association for the Advancement of Science," and their successors, are hereby made a corporation by the name of the "American Association for the Advancement of Science," for the purpose of receiving, purchasing, holding and conveying real and personal property, which it now is, or hereafter may be, possessed of, with all the powers and privileges, and subject to the restrictions, duties and liabilities set forth in the general laws which now or hereafter may be in force and applicable to such corporations.

Section 2. Said corporation may have and hold by purchase, grant, gift or otherwise, real estate not exceeding one hundred thousand dollars in value, and personal estate of the value of two hundred and fifty thousand dollars.

Section 3. Any two of the corporators above named are hereby authorized to call the first meeting of the said corporation in the month of August next ensuing, by notice thereof "by mail," to each member of the said Association.

Section 4. This act shall take effect upon its passage.

House of Representatives, March 10, 1874.
Passed to be enacted,
John E. Sanford, *Speaker*.

In Senate, March 17, 1874.
Passed to be enacted,
Geo. B. Loring, *President*.

March 19, 1874.
Approved,
W. B. Washburn.

Secretary's Department,
Boston, April 8, 1874.
A true copy, Attest:
David Pulsifer,
Deputy Secretary of the Commonwealth.

CONSTITUTION

OF THE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Incorporated by Act of the General Court of the Commonwealth of Massachusetts.

OBJECTS.

ARTICLE 1. The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness.

MEMBERS, FELLOWS, PATRONS AND HONORARY FELLOWS.

ART. 2. The Association shall consist of Members, Fellows, Patrons, and Honorary Fellows.

ART. 3. Any person may become a Member of the Association upon recommendation in writing by two members or fellows, and election by the Council.

ART. 4. Fellows shall be elected by the Council from such of the members as are professionally engaged in science, or have by their labors aided in advancing science. The election of fellows shall be by ballot and a majority vote of the members of the Council at a designated meeting of the Council.

ART. 5. Any person paying to the Association the sum of one thousand dollars shall be classed as a Patron, and shall be entitled to all the privileges of a member and to all its publications.

ART. 6. Honorary Fellows of the Association, not exceeding three for each section, may be elected; the nominations to be made by the Council and approved by ballot in the respective sections before election by ballot in General Session. Honorary Fellows shall be entitled to all the privi-

leges of Fellows and shall be exempt from all fees and assessments, and entitled to all publications of the Association issued after the date of their election.

ART. 7. The name of any member or fellow two years in arrears for annual dues shall be erased from the list of the Association, provided that two notices of indebtedness, at an interval of at least three months, shall have been given; and no such person shall be restored until he has paid his arrearages or has been reëlected. The Council shall have power to exclude from the Association any member or fellow, on satisfactory evidence that said member or fellow is an improper person to be connected with the Association, or has in the estimation of the Council made improper use of his membership or fellowship.

ART. 8. No member or fellow shall take part in the organization of, or hold office in, more than one section at any one meeting.

OFFICERS.

ART. 9. The Officers of the Association shall be elected by ballot in General Session from the fellows, and shall consist of a President, a Vice President from each section, a Permanent Secretary, a General Secretary, a Secretary of the Council, a Treasurer, and a Secretary of each Section; these, with the exception of the Permanent Secretary, shall be elected at each meeting for the following one, and, with the exception of the Treasurer and the Permanent Secretary, shall not be reëligible for the next two meetings. The term of office of Permanent Secretary shall be five years.

ART. 10. The President, or, in his absence, the senior Vice President present, shall preside at all General Sessions of the Association and at all meetings of the Council. It shall also be the duty of the President to give an address at a General Session of the Association at the meeting following that over which he presided.

ART. 11. The Vice Presidents shall be the chairmen of their respective Sections, and of their Sectional Committees, and it shall be part of their duty to give an address, each before his own section, at such time as the Council shall determine. The Vice Presidents may appoint temporary chairmen to preside over the sessions of their sections, but shall not delegate their other duties. The Vice Presidents shall have seniority in order of their continuous membership in the Association.

ART. 12. The General Secretary shall be the Secretary of all General Sessions of the Association, and shall keep a record of the business of

these sessions. He shall receive the records from the Secretaries of the Sections, which, after examination, he shall transmit with his own records to the Permanent Secretary within two weeks after the adjournment of the meeting.

ART. 13. The Secretary of the Council shall keep the records of the Council. He shall give to the Secretary of each Section the titles of papers assigned to it by the Council. He shall receive proposals for membership and bring them before the Council.

ART. 14. The Permanent Secretary shall be the executive officer of the Association under the direction of the Council. He shall attend to all business not specially referred to committees nor otherwise constitutionally provided for. He shall keep an account of all business that he has transacted for the Association, and make annually a general report for publication in the annual volume of Proceedings. He shall attend to the printing and distribution of the annual volume of Proceedings, and all other printing ordered by the Association. He shall issue a circular of information to members and fellows at least three months before each meeting, and shall, in connection with the Local Committee, make all necessary arrangements for the meetings of the Association. He shall provide the Secretaries of the Association with such books and stationery as may be required for their records and business, and shall provide members and fellows with such blank forms as may be required for facilitating the business of the Association. He shall collect all assessments and admission fees, and notify members and fellows of their election, and of any arrearages. He shall receive, and bring before the Council, the titles and abstracts of papers proposed to be read before the Association. He shall keep an account of all receipts and expenditures of the Association, and report the same annually at the first meeting of the Council, and shall pay over to the Treasurer such unexpended funds as the Council may direct. He shall receive and hold in trust for the Association all books, pamphlets and manuscripts belonging to the Association, and allow the use of the same under the provisions of the Constitution and the orders of the Council. He shall receive all communications addressed to the Association during the interval between meetings, and properly attend to the same. He shall at each meeting report the names of fellows and members who have died since the preceding meeting. He shall be allowed a salary which shall be determined by the Council, and may employ one or more clerks at such compensation as may be agreed upon by the Council.

ART. 15. The Treasurer shall invest the funds received by him in such securities as may be directed by the Council. He shall annually present to the Council an account of the funds in his charge. No expenditure of the principal in the hands of the Treasurer shall be made without a unanimous vote of the Council, and no expenditure of the income received by the Treasurer shall be made without a two-thirds vote of the Council.

ART. 16. The Secretaries of the Sections shall keep the records of their respective sections, and, at the close of the meeting, give the same, including the records of subsections, to the General Secretary. They shall also be the Secretaries of the Sectional Committees. The Secretaries shall have seniority in order of their continuous membership in the Association.

ART. 17. In case of a vacancy in the office of the President, one of the Vice Presidents shall be elected by the Council as the President of the meeting. Vacancies in the offices of Vice President, Permanent Secretary, General Secretary, Secretary of the Council, and Treasurer, shall be filled by nomination of the Council and election by ballot in General Session. A vacancy in the office of Secretary of a Section shall be filled by nomination and election by ballot in the Section.

ART. 18. The Council shall consist of the past Presidents, and the Vice Presidents of the last meeting, together with the President, the Vice Presidents, the Permanent Secretary, the General Secretary, the Secretary of the Council, the Secretaries of the Sections, and the Treasurer of the current meeting, with the addition of one fellow elected from each Section by ballot on the first day of its meeting. The members present at any regularly called meeting of the Council, provided there are at least five, shall form a quorum for the transaction of business. The Council shall meet on the day preceding each annual meeting of the Association, and arrange the programme for the first day of the sessions. The time and place of this first meeting shall be designated by the Permanent Secretary. Unless otherwise agreed upon, regular meetings of the Council shall be held in the council room at 9 o'clock, A.M., on each day of the meeting of the Association. Special meetings of the Council may be called at any time by the President. The Council shall be the board of supervision of the Association, and no business shall be transacted by the Association that has not first been referred to, or originated with, the Council. The Council shall receive and assign papers to the respective sections; examine and, if necessary, exclude papers; decide which papers,

discussions and other proceedings shall be published, and have the general direction of the publications of the Association; manage the financial affairs of the Association; arrange the business and programmes for General Sessions; suggest subjects for discussion, investigation or reports; elect members and fellows; and receive and act upon all invitations extended to the Association and report the same at a General Session of the Association. The Council shall receive all reports of Special Committees and decide upon them, and only such shall be read in General Session as the Council shall direct. The Council shall appoint at each meeting the following sub-committees who shall act, subject to appeal to the whole Council, until their successors are appointed at the following meeting: 1, on Papers and Reports; 2, on Members; 3, on Fellows.

ART. 19. The Nominating Committee shall consist of the Council, and one member or fellow elected by each of the Sections. It shall be the duty of this Committee to meet at the call of the President and nominate the general officers for the following meeting of the Association. It shall also be the duty of this Committee to recommend the time and place for the next meeting. The Vice President and Secretary of each Section shall be recommended to the Nominating Committee by a sub-committee consisting of the Vice President, Secretary, and three members or fellows elected by the Section.

MEETINGS.

ART. 20. The Association shall hold a public meeting annually, for one week or longer, at such time and place as may be determined by vote of the Association, and the preliminary arrangements for each meeting shall be made by the Local Committee, in conjunction with the Permanent Secretary and such other persons as the Council may designate.

ART. 21. A General Session shall be held at 10 o'clock A. M., on the first day of the meeting, and at such other times as the Council may direct.

SECTIONS AND SUBSECTIONS.

ART. 22. The Association shall be divided into Sections, namely:— A, *Mathematics and Astronomy;* B, *Physics;* C, *Chemistry, including its application to agriculture and the arts;* D, *Mechanical Science and Engineering;* E, *Geology and Geography;* F, *Biology*; [G, united to section F]; H, *Anthropology;* I, *Economic Science and Statistics.* The Council shall have power to consolidate any two or more Sections temporarily, and such consolidated Sections shall be presided over by the senior Vice President and Secretary of the Sections comprising it.

ART. 23. Immediately on the organization of a Section there shall be three fellows elected by ballot after open nomination, who, with the Vice President and Secretary, shall form its Sectional Committee. The Sectional Committees shall have power to fill vacancies in their own numbers. Meetings of the Sections shall not be held at the same time with a General Session.

ART. 24. The Sectional Committee of any Section may at its pleasure form one or more temporary Subsections, and may designate the officers thereof. The Secretary of a Subsection shall, at the close of the meeting, transmit his records to the Secretary of the Section.

ART. 25. A paper shall not be read in any Section or Subsection until it has been received from the Council and placed on the programme of the day by the Sectional Committee.

SECTIONAL COMMITTEES.

ART. 26. The Sectional Committees shall arrange and direct the business of their respective Sections. They shall prepare the daily programmes and give them to the Permanent Secretary for printing at the earliest moment practicable. No titles of papers shall be entered on the daily programmes except such as have passed the Council. No change shall be made in the programme for the day in a Section without the consent of the Sectional Committee. The Sectional Committees may refuse to place the title of any paper on the programme; but every such title, with the abstract of the paper or the paper itself, must be returned to the Council with the reasons why it was refused.

ART. 27. The Sectional Committees shall examine all papers and abstracts referred to the sections, and they shall not place on the programme any paper inconsistent with the character of the Association; and to this end they have power to call for any paper, the character of which may not be sufficiently understood from the abstract submitted.

PAPERS AND COMMUNICATIONS.

ART. 28. All members and fellows must forward to the Permanent Secretary, as early as possible, and when practicable before the convening of the Association, full titles of all the papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery, and also such abstracts of their contents as will give a general idea of their nature; and no title shall be referred by the Council to the Sectional Committee until an abstract of the paper or the paper itself has been received.

ART. 29. If the author of any paper be not ready at the time assigned, the title may be dropped to the bottom of the list.

ART. 30. Whenever practicable, the proceedings and discussions at General Sessions, Sections and Subsections shall be reported by professional reporters, but such reports shall not appear in print as the official reports of the Association unless revised by the Secretaries.

PRINTED PROCEEDINGS.

ART. 31. The Permanent Secretary shall have the Proceedings of each meeting printed in an octavo volume as soon after the meeting as possible, beginning one month after adjournment. Authors must prepare their papers or abstracts ready for the press, and these must be in the hands of the Secretaries of the Sections before the final adjournment of the meeting, otherwise only the titles will appear in the printed volume. The Council shall have power to order the printing of any paper by abstract or title only. Whenever practicable, proofs shall be forwarded to authors for revision. If any additions or substantial alterations are made by the author of a paper after its submission to the Secretary, the same shall be distinctly indicated. Illustrations must be provided for by the authors of the papers, or by a special appropriation from the Council. Immediately on publication of the volume, a copy shall be forwarded to every member and fellow of the Association who shall have paid the assessment for the meeting to which it relates, and it shall also be offered for sale by the Permanent Secretary at such price as may be determined by the Council. The Council shall also designate the institutions to which copies shall be distributed.

LOCAL COMMITTEE.

ART. 32. The Local Committee shall consist of persons interested in the objects of the Association and residing at or near the place of the proposed meeting. It is expected that the Local Committee, assisted by the officers of the Association, will make all essential arrangements for the meeting, and issue a circular giving necessary particulars, at least one month before the meeting.

LIBRARY OF THE ASSOCIATION.

ART. 33. All books and pamphlets received by the Association shall be in the charge of the Permanent Secretary, who shall have a list of the same printed and shall furnish a copy to any member or fellow on application. Members and fellows who have paid their assessments in full shall be allowed to call for books and pamphlets, which shall be delivered to them at their expense, on their giving a receipt agreeing to make good any loss or damage and to return the same free of expense to the Secretary at the time specified in the receipt given. All books and pamphlets

in circulation must be returned at each meeting. Not more than five books, including volumes, parts of volumes, and pamphlets, shall be held at one time by any member or fellow. Any book may be withheld from circulation by order of the Council.

Admission Fee and Assessments.

Art. 34. The admission fee for members shall be five dollars in addition to the annual assessment. On the election of any member as a fellow an additional fee of two dollars shall be paid.

Art. 35. The annual assessment for members and fellows shall be three dollars.

Art. 36. Any member or fellow who shall pay the sum of fifty dollars to the Association, at any one time, shall become a Life Member and as such shall be exempt from all further assessments, and shall be entitled to the Proceedings of the Association. All money thus received shall be invested as a permanent fund, the income of which, during the life of the member, shall form a part of the general fund of the Association; but, after his death, shall be used only to assist in original research, unless otherwise directed by unanimous vote of the Council.

Art. 37. All admission fees and assessments must be paid to the Permanent Secretary, who shall give proper receipts for the same.

Accounts.

Art. 38. The accounts of the Permanent Secretary and of the Treasurer shall be audited annually, by Auditors appointed by the Council.

Alterations of the Constitution.

Art. 39. No part of this Constitution shall be amended or annulled, without the concurrence of three-fourths of the members and fellows present in General Session, after notice given at a General Session of a preceding meeting of the Association.

ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

1. The retiring President introduces the President elect, who takes the chair.
2. Formalities of welcome of the Association as may be arranged by the Local Committee.
3. Report of the list of papers entered and their reference to the Sections.
4. Other reports.
5. Announcements of arrangements by the Local Committee.
6. Announcements of Elections by the Council.
7. Unenumerated business.
8. Adjournment to meet in Sections.

This order, so far as applicable, to be followed in subsequent General Sessions.

MEMBERS

OF THE

AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.[1]

PATRONS.[2]

THOMPSON, MRS. ELIZABETH, Stamford, Conn. (22).
LILLY, GEN. WILLIAM, Mauch Chunk, Carbon Co., Pa. (28). **F E**
HERRMAN, MRS. ESTHER, 59 West 56th St., New York, N. Y. (29).

MEMBERS.[3]

Abbe, Robert, 11 W. 50th St., New York, N. Y. (36).
Abbott, James, 1509 Locust St., Philadelphia, Pa. (34).
Abert, S. Thayer, 810 19th St., N. W., Washington, D. C. (30). **A B D E I**
Adams, Chas. Francis, High School, Detroit, Mich. (34). **C B**
Adams, W. H., Consulting Engineer, 71 Wall St., New York, N. Y. (36).
Agard, Dr. A. H., 1259 Alice St., Oakland, Alameda Co., Cal. (28).
Aher, Mrs. Mary R. Alling, Waterbury, Conn. (29). **E F C**
Alberger, Louis R., 1181 Delaware Ave., Buffalo, N. Y. (35). **C**
Alden, Jno., Pacific Mills, Lawrence, Mass. (36).

[1] The numbers in parentheses indicate the meeting at which the member was elected. The black letters at the end of line indicate the sections to which members elect to belong. The Constitution requires that the names of all members two or more years in arrears shall be omitted from the list, but their names will be restored on payment of arrearages. Members not in arrears are entitled to the annual volume of Proceedings bound in paper. *The payment of ten dollars at one time entitles a member to the subsequent volumes to which he may be entitled, bound in cloth, or by the payment of twenty dollars, to such volumes bound in half morocco.*

[2] Persons contributing one thousand dollars or more to the Association are classed as Patrons, and are entitled to the privileges of members and to the publications. The names of Patrons are to remain permanently on the list.

[3] Any Member or Fellow may become a Life Member by the payment of fifty dollars. The income of the money derived from a Life Membership is used for the general purposes of the Association during the life of the member; afterwards it is to be used to aid in original research. Life Members are exempt from the annual assessment, and are entitled to the annual volume. The names of Life Members are printed in small capitals in the regular list of Members and Fellows.

Alexander, Miss Jane, Jamaica Plain, Mass. (33). F
Allderdice, Wm. H., U. S. Navy, care Navy Department, Washington, D. C. (33). D
Allen, Addison, 50 Wall St., New York, N. Y. (36).
Allen, Dudley P., 177 Euclid Ave., Cleveland, Ohio (36) F
Allen, Henry C., M.D., Ann Arbor, Mich. (34). C F
Allen, J. M., Hartford, Conn. (22). D
Allen, W. F., 46 Bond St., New York, N. Y. (36).
Alvord, Benjamin, 2nd Lt. 20th Infantry, U. S. A., Fort Leavenworth, Kan. (33). A
Anderson, Newton M., 371 Sibley St., Cleveland, Ohio (30). B
Angell, Geo. W. J., 44 Hudson St., New York, N. Y. (36).
Ansley, Clark F., Swedona, Mercer Co., Ill. (32). E H
Antisell, Thomas, M.D., 1311 Q St., N.W., Washington, D. C. (33). C E
Appleton, Rev. Edw. W., D.D., Ashbourne P. O., Montgomery Co., Pa. (28).
Archambault, U. E., P. O. box 1944, Montreal, Can. (31).
Arey, Albert L., Free Academy, Rochester, N. Y. (35). B C
Arms, Walter F., Punxsutawney, Jefferson Co., Pa. (35).
Atkinson, Charles Heath, Brookline, Mass. (34). D I
Atkinson, Jno. B., Earlington, Hopkins Co., Ky. (26). D
Atterbury, Rev. Anson Phelps, 115 W. 87th St., New York, N. Y. (36). E
Atwell, Charles B., 461 Emerson St., Evanston, Ill. (36). F
Atwood, E. S., East Orange, N. J. (29). F
Austin, Wm., 65 Union Place, New York, N. Y. (36).
AVERY, SAMUEL P., 4 E. 38th St., New York, N. Y. (36).

Baba, Tatui, 126 W. 42nd St., New York, N. Y. (36). H
Babbitt, Miss Franc E., Lock Box 1284, Coldwater, Mich. (32). H I
Babcock, Geo. H., 30 Cortlandt St., New York, N. Y. (33). D
Bacon, Prof. Chas. A., Observatory Beloit College, Beloit, Wis. (36) A
Bailey, E. H. S., Lawrence, Douglas Co., Kan. (25). C E
Bailey, Prof. Liberty H., jr., Agricultural College, Mich. (34). F
Baker, Achbor J., Ann Arbor, Mich. (34). F H I
Baker, Henry Brooks, 726 Ottawa St., Lansing, Mich. (34). F C I B
Baker, Prof. I. O., Univ. of Illinois, Champaign, Ill. (30.) A D
Baker, Richard D., 1414 Arch St., Philadelphia, Pa. (33). E C
Baker, Wm. G., 234 E. 15th St., New York, N. Y. (36).
Balderston, C. Canby, Westtown, Chester Co., Pa. (33). B
Baldwin, Miss Mary A., Summer Ave., Cor. Kearney St., Newark, N. J. (31). E
Baldwin, Mrs. S., 3 Madison Ave., Detroit, Mich. (34). H
Ballard, Harlan H., 50 South St., Pittsfield, Mass. (31). E F
Balliard, Chas., Metropolitan Museum of Art, New York, N. Y. (36).
Banes, Charles H., 2021 Spring Garden St., Philadelphia, Pa. (31). D
BANGS, LEMUEL BOLTON, M.D., 127 E. 34th St., New York, N. Y. (36).
Barber, John N., 1317 Hennepin Ave., Minneapolis, Minn. (33). F

Barclay, Robert, A.M., M.D., 3211 Lucas Ave., St. Louis, Mo. (30).
Bardeen, Francis L., M.D., Box 76, Onondaga Hill, N. Y. (32). C F B
Barge, B. F., Mauch Chunk, Pa. (33).
Barker, Mrs. Martha M., 26 Eleventh St., Lowell, Mass. (31). E H
Barnett, J. Davis, Port Hope, Ontario, Can. (34). D B
Barnum, Miss Charlotte C., 144 Humphrey St., New Haven, Conn. (36). A
Barnum, Thomas R., 144 Humphrey St., New Haven, Conn. (35). E
Barrett, Dwight H., B. & O. R. R. Co., Baltimore, Md. (36).
Bartlett, John W., M.D., 149 W. 94th St., New York, N. Y. (36).
Bartley, Elias H., M.D., 401 Pacific St., Brooklyn, N. Y. (33). C
Bassett, Norman C., Prof. Mechanical Engineering, Iowa College of Agric. and Mechanical Arts, Ames, Iowa (35). D
Battershall, Jesse Park, 402 Washington St., New York, N. Y. (36).
Batterson, J. G., Hartford, Conn. (23).
Battle, Herbert B., N. C. Agric. Exper. Station, Raleigh, N. C. (33). C
Baur, George, New Haven, Conn. (36).
Baxter, James N., 273 Henry St., Brooklyn, N. Y. (36).
Baxter, Sylvester, office of the Herald, Boston, Mass. (36). H
Baylor, James B., U. S. Coast and Geodetic Survey Office, Washington, D. C. (33). A
Beach, William H., Madison, Wis. (21). E B
Bean, Thos. E., Box 441, Galena, Ill. (28). F
Beaudry, J. Alphonse U., 99 St. James St., Montreal, Can. (31). D B
Beauregard, Gen. Gustave T., 359 St. Charles Avenue, New Orleans, La. (30). A B
Bechdolt, Adolphus F., Supt. City Schools, Mankato, Minn. (32). E B F
Becker, Dr. Geo. F., U. S. Geol. Survey, San Francisco, Cal. (36). E
Belknap, Morris B., Louisville, Ky. (29). H E
Belknap, Wm. B., Louisville, Ky. (29). D
Bell, C. M., M.D., 320 Fifth Ave., New York, N. Y. (36).
Benjamin, E. B., 6 Barclay St., New York, N. Y. (19). B C
Bennett, Prof. Wm. Z., Wooster, Wayne Co., Ohio (33). C
Beveridge, David, 145 Griswold St., Detroit, Mich. (33). I
Bien, Julius, 139 Duane St., New York, N. Y. (34). E H
Bigelow, Prof. Frank H., Racine, Wis. (36). A
Bigelow, Otis, 605 7th St., Washington, D. C. (30). H F
Bigelow, Robert P., Washington, D. C. (32). F E
Bill, Charles, Springfield, Mass. (17). H F I
Bingham, Mrs. Martha A., Hotel Brunswick, Kansas City, Mo. (32).
Birge, Charles P., Keokuk, Iowa (29). E
Bishop, Heber R., Mills Building, New York, N. Y. (36).
Bishop, Irving P., Chatham, Columbia Co., N. Y. (35). E
Bixby, Wm. H., Wilmington, N. C. (34). D
Blacklock, Charles H., Rugby, Tenn. (35).
Blackwell, Mrs. A. B., Elizabeth, N. J. (30). F C B
Blaisdell, F. E., Coronado, San Diego Co., Cal. (29). F
Blake, Francis C., Mansfield Valley P. O., Allegheny Co., Pa. (29). C B D

Blake, L. I., Hyde Park, Mass. (36).
Blakslee, Prof. T. M., Des Moines, Iowa (31). A
Blankenburg, Rudolf, 1326 Arch St., Philadelphia, Pa. (33). I
Blatchford, Eliphalet W., 375 La Salle Ave., Chicago, Ill. (17). F
Blish, W. G., Niles, Mich. (33). B D
Blount, Henry F., Evansville, Vanderburg Co., Ind. (32). I B
Blount, Mrs. Lucia E., 518 Unity Square, Kalamazoo, Mich. (34). H I
Blue, Archibald, Ass't Minister of Agric., Toronto, Can. (35). I
Boas, Dr. Franz, 47 Lafayette Place, New York, N. Y. (36).
Bohannan, R. W., University of Virginia, Va. (36).
Booraem, J. V. V., 204 Lincoln Place, Brooklyn, N. Y. (36).
Booth, Miss Mary A., Longmeadow, Mass. (34). F I
Booth, Samuel C., Longmeadow, Mass. (34). E I
Bothwell, Geo. W., M.A., Southern University, New Orleans, La. (36).
Bourland, Addison M., M.D., Van Buren, Ark. (29). C E F
Bourne, Robert W., Box 217, Providence, R. I. (34). D
Bowers, Miss Virginia K., 1 McCall St., Memphis, Tenn. (27). F H B C
Bowman, Chas. G., Lt. U. S. N., care Navy Dept., Washington, D.C. (33)
Bowser, Mrs. Anna C., 828 Third St., Louisville, Ky. (33). H
Boyer, Jerome L., Sup't Chestnut Hill Iron Ore Co., Reading, Pa. (35). D
Bradford, Edward H., M.D., 150 Boylston St., Boston, Mass. (29).
Bradford, Royal B., Lt. Comd'r, U. S. N., care of Navy Department, Washington, D. C. (31). B D
Braid, Andrew, U. S. Coast and Geodetic Survey Office, Washington, D. C. (33). C B A
Braid, James W., Nashville, Tenn. (33).
Braley, Sam'l T., Rutland, Vt. (33). D B
Bransford, John Francis, Surgeon U. S. N., Smithsonian Institution, Washington, D. C. (36) H I
Bray, Prof. C. D., College Hill, Mass. (29). D B
Brayton, Miss Sarah H., M.D., Evanston, Ill. (33).
Breckinridge, S. M., P. O. Box 346, St. Louis, Mo. (27).
Breidenbaugh, Prof. E. S., Pennsylvania College, Gettysburg, Pa. (33). C
Brice, Judge Albert G., 122 Gravier St., New Orleans, La. (32). H
Brill, Prof. Charles C., Northfield, Vt. (36). F
Bringhurst, Prof. W. L., Agric. and Mechan. College of Texas, College Station, Brazos Co., Texas (32).
Bristol, Wm. H., Stevens Institute, Hoboken, N. Y. (36). A B D
Britton, Mrs. N. L., Columbia College, New York, N. Y. (31). F
Bromfield, Rev. Edw. T., Glenbrook, Fairfield Co., Conn. (33). F H
Brooke, Dr. Emma W., 15th and Chestnut Sts., Phila., Pa. (33). C E
Broomall, Hon. John M., Media, Delaware Co., Pa. (23). A
Brown, Albert P., Ph.D., 501 Federal St., Camden, N. J. (33). F C
Brown, Miss Anna M., 528 West 7th St., Cincinnati, Ohio (31). F
Brown, Prof. C. J., Clark Univ., Atlanta, Ga. (31). C B
Brown, C. Newton, Ohio State Univ., Columbus, Ohio (34).
Brown, Fred. G., Fort Ann, Washington Co., N. Y. (31). C E

Brown, Rev. Henry M., East Aurora, Erie Co., N. Y. (35). F C
Brown, Jonathan, 390 Broadway, Somerville, Mass. (29).
Brown, Paul Taylor, 2206 Green St., Philadelphia, Pa. (33). E
Brownell, Silas B., 71 Wall St., New York, N. Y. (36).
Brownell, Prof. Walter A., 125 Univ. Ave., Syracuse, N. Y. (30). E B C
Buck, Henry C., West Somerville, Mass. (29). B
Buckingham, Chas. L., 195 Broadway, New York, N. Y. (28).
Buffum, Miss Fannie A., Linden, Mass. (29). E C
Bulloch, Walter H., 99 W. Monroe St., Chicago, Ill. (30). F
Burchard, Wm. M., M.D., Uncasville, Conn. (33). B
Burke, William, U. S. Patent Office, Washington, D. C. (28).
Burnett, Chas. H., M.D., 127 So. 18th St., Philadelphia, Pa. (35). F B
Burns, Prof. James A., Box 456, Atlanta, Ga. (32). C E I
Burr, Mrs. Laura E., Commercial Hotel, Lansing, Mich. (34). B
Bush, Rev. Stephen, D.D., Waterford, N. Y. (19). E H
Byrd, Mary E., Carleton College, Northfield, Minn. (34). A

Cabot, John W., Bellaire Nail Works, Bellaire, Belmont Co., Ohio (35). D
Cady, Calvin B., Ann Arbor, Mich. (34).
Calder, Edwin E., Board of Trade Building, Providence, R. I. (29). C
Calkins, Dr. Marshall, Springfield, Mass. (29).
Campbell, Andrew, Ypsilanti, Mich. (34). I H E
Campbell, Douglas H., 91 Alfred St., Detroit, Mich. (34). F
Campbell, Prof. J. L., Wabash College, Crawfordsville, Ind. (34). B A D
Campbell, Rev. Prof. John, Presbyterian College, Montreal, Can. (31). H
Campbell, Jos. Addison, Pulaski and Logan Sts., Germantown, Pa. (33).
Campbell, Wm. A., M.D., Ann Arbor, Mich. (34). F B
Capen, Miss Bessie T., Northampton, Mass. (23). C
Cardeza, John M., M.D., Claymont, Del. (33). E
Carman, Charles W., 5 N. Ingalls St., Ann Arbor, Mich. (34). B A
Carman, Lewis, Bangall, N. Y. (29). E H
Caron, C. K., Louisville, Ky. (30). E C
Carpenter, Geo. O., jr., care of St. Louis Lead and Oil Co., St. Louis, Mo. (29).
Carpenter, Louis G., Agricultural College, Lansing, Mich. (32). A B
Carpenter, Prof. R. C., Agricultural College, Lansing, Mich. (33). D A
Carroll, Alfred L., M.D., New Brighton, Staten Island, N. Y. (36). F
Carrington, Col. Henry B., U. S. A., 22 Bromfield St., Boston, Mass. (20).
CARTER, JAMES C., 277 Lexington Ave., New York, N. Y. (36).
Carter, John E., Knox and Coulter Sts., Germantown, Pa. (33). B H
Cary, Albert A., 234 W. 29th St., New York, N. Y. (36).
Catlin, Charles A., 12 Cooke St., Providence, R. I. (33). C
Causey, Francis F., Hampton, Va. (36) I
Chadbourn, Erlon R., Lewiston, Me. (29).
Chahoon, Mrs. Mary D., 134 S. Fourth St., Philadelphia, Pa. (33).
Champlin, John D., Jr., 745 Broadway, New York, N. Y. (36).

Chandler, Prof. John R., National Institute, Guatemala, Central America (36) F H
Charbonnier, Prof. L. H., University of Georgia, Athens, Ga. (26). A B D
Chase, Mrs. Mariné J., 1622 Locust St., Philadelphia, Pa. (31). E F
Chase, R. Stuart, 53 Summer St., Haverhill, Mass. (18). F
Chatfield, A. F., Albany, N. Y. (29).
Chester, Commander Colby M., U. S. N., care Navy Dep't, Washington, D. C. (28). E
Chester, Prof. Frederick D., Delaware State College, Newark, Del. (33). E
Childe, John Healey, 12 Brimmer St., Boston, Mass. (31).
Christie, James, Pencoyd, Pa. (33). D
Christy, Prof. Samuel B., Box 41, Berkeley, Cal. (35). D
Chrystie, Wm. F., Hastings-on-Hudson, New York, N. Y. (36).
Church, W. C., 240 Broadway, New York, N. Y. (36).
Chute, Horatio N., Ann Arbor, Mich. (34). B C A
Clapp, Geo. H., 98 Fourth Ave., Pittsburgh, Pa. (33). H C
Clark, Alex S., Westfield, N. J. (33).
Clark, John S., 7 Park St., Boston, Mass. (31). I B C
Clark, Simeon T., M.D., 103 Genesee St., Lockport, Niagara Co., N. Y. (25). F
Clark, Wm. Brewster, M.D., 50 E. 31st St., New York, N. Y. (33). F C
Clarke, Charles S., 130 Moss St., Peoria, Ill. (34).
Clarke, Robert, Cincinnati, Ohio (30). H
Clement, F. H., Ardsley, N. Y. (33). D E
Clute, Rev. Oscar, Iowa City, Iowa (34). I F
Coakley, George W., LL.D., Hempstead, L. I. (29). A B D
Cobb, Samuel C., 235 Boylston St., Boston, Mass. (29).
COE, HENRY W., M.D., Mandan, Dakota (32). H F
Coffin, Amory, Phœnixville, Chester Co., Pa. (31). D
Coffin, Charles L., cor. Leib and Franklin Sts., Detroit, Mich. (34). C
Coffinberry, W. L., 135 Summit St., Grand Rapids, Mich. (20). B D H
Cogswell, W. B., Syracuse, N. Y. (33). D
Coit, J. Milner, Ph.D., Saint Paul's School, Concord, N. H. (33). B C E
Colburn, Dr. E. M., 207 S. Jefferson St., Peoria, Ill. (33). H
COLBURN, RICHARD T., Elizabeth, N. J. (31). I
Coles, D. S., A.M, M.D., Wakefield, Mass. (35). F
Colie, Edw. M., East Orange, N. J. (30). E I
Collin, Prof. Alonzo, Cornell College, Mount Vernon, Iowa (21). B C
Collingwood, Francis, Elizabeth, N. J. (36).
Collins, Anna E., Germantown, Pa. (36).
Collins, Charles, 133 E. 36th St., New York, N. Y. (36).
Collins, Miss Fanny W., Greenwich, Conn. (36).
Colman, Henry, M.D., 34 Nahant St., Lynn, Mass. (25). F
Colton, Buel P., Ottawa, Ill. (34). F
Colton, G. Woolworth, 182 William St., New York, N. Y. (22).
Comstock, Dr. T. Griswold, 507 North 14th St., St. Louis, Mo. (29). F H

Conant, Miss E. Ida, 42 West 48th St., New York, N. Y. (33). H I F
Condit, Charles L., 743 Broadway, New York, N. Y. (34).
Conklin, W. A., Director Central Park Menagerie, New York, N. Y. (29). F
Cook, Dr. Charles D., 133 Pacific St., Brooklyn, N. Y. (25).
Cook, Chas. Sumner, Hanover, N. H. (36). B
Cook, Martin W., Rochester, N. Y. (36).
Coon, Henry C., M.D., Alfred Centre, N. Y. (29). B C F
Cope, Miss Mary S., Awbury, Germantown, Pa. (33). I
Cope, Thos. P., Awbury, Germantown, Pa. (33). I
Coulter, Prof. Stanley, Coates College, Terre Haute, Ind. (35). F
Coville, A. L., Oxford, Chenango Co., N. Y. (35). E F
Coville, Frederick V., Oxford, Chenango Co., N. Y. (35). F
Cowell, Jno. F., Buffalo, N. Y. (35).
Crafts, Robert H., 2329 So. 6th St., Minneapolis, Minn. (32). I B
Cragin, Francis W., Washburn College, Topeka, Kan. (29). F E H
Craig, Thomas, Tompkinsville, Staten Island, N. Y. (36). F
Crawford, Prof. Morris B., Middletown, Conn. (30). B
Crosier, Dr. Edward S., New Albany, Ind. (29). F
CROWELL, A. F., Woods Holl, Mass. (30). C
Crozier, A. S., Dept. of Agric., Washington, D. C. (36).
Cruikshank, James, LL.D., 206 So. Oxford St., Brooklyn, N. Y. (36).
Crump, M. H., Col. Commanding 3d Reg. K. S. G., Bowling Green, Ky. (29). E
Culin, Stewart, 127 South Front St., Philadelphia, Pa. (33). H
Culver, Dr. S. H., Mason, Mich. (34). F
Cunningham, Francis A., 1613 Wallace St., Philadelphia, Pa. (33). D E B
Cunz, Johannes H., 137 Hudson St., Hoboken, N. J. (36).
Currier, John McNab, M.D., Castleton, Vt. (28). H F E
Curtis, Edw., M.D., 120 Broadway, New York, N. Y. (36).
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HONORARY FELLOWS.[1]

ROGERS, WILLIAM B., Boston, Mass. (1). 1881. (Died in 1882.)
CHEVREUL, MICHEL EUGÈNE, Paris (35). 1886.

FELLOWS.[2]

Aaron, Eugene M., 331 Walnut St., Philadelphia, Pa. (33). 1886. **F**
Abbe, Professor Cleveland, Army Signal Office, Washington, D. C. (16). 1874. **B A**
Abbott, Dr. Chas. C., Trenton, N. J. (29). 1883. **F H**
Abbott, Miss Helen C. De S., 1509 Locust St., Philadelphia, Pa. (33). 1885. **C F**
Adams, Frank Dawson, 141 Rideau St., Ottawa, Can. (29). 1885.
Alden, Prof. Geo. I., Worcester, Mass. (33). 1885. **D**
Alexander, John S., 1935 Arch St., Philadelphia, Pa. (20). 1874. **B C D**
Allen, Dr. Harrison, 117 S. 20th St., Philadelphia, Pa. (29). 1882. **F**
Allen, Joel A., American Museum of Natural History, Central Park, New York (18). 1875. **F**
Allen, Dr. T. F., 10 E. 36th St., New York, N. Y. (35). 1887. **F**
Alvord, Henry E., C.E., Amherst, Mass. (29). 1882. **I**
Ammen, Daniel, Rear Admiral U. S. Navy, Beltsville, Md. (26). 1881. **E**
Anderson, Dr. Joseph, Waterbury, Conn. (29). 1883. **H**
Anthony, Prof. Wm. A., Cornell Univ., Ithaca, N. Y. (28). 1880. **B**
Arthur, J. C., Geneva, N. Y. (21). 1883. **F**
Ashburner, Charles A., Penn Building, Pittsburgh, Pa. (31). 1883. **E**
Atkinson, Edward, 31 Milk St., Boston, Mass. (29). 1881. **I D**
Atwater, Prof. W. O., Wesleyan Univ., Middletown, Conn. (29). 1882. **C**
Auchincloss, Wm. S., 209 Church St., Philadelphia, Pa. (29). 1886. **D A**
Austen, Peter T., Ph.D., Rutgers College, Lock Box No. 2, New Brunswick, N. J. (26). 1879. **C**
Ayres, Prof. Brown, Tulane University, New Orleans, La. (31). 1885. **B**
Ayres, Howard, Museum Comp. Zoology, Cambridge, Mass. (34). 1886. **F**

Babcock, S. Moulton, N. Y. Agricultural Experiment Station, Geneva, N. Y. (33). 1885. **C**
Bailey, Prof. W. W., Brown University, Providence, R. I. (18). 1874. **F**
Baker, Frank, M.D., 1315 Corcoran St., Washington, D. C. (31). 1886. **F H**

[1] See ARTICLE VI of the Constitution. [2] See ARTICLE IV of the Constitution.

*** The number in parenthesis indicates the meeting at which the member joined the Association; the date following is the year when made a Fellow; the black letters at end of line are those of the sections to which the fellow belongs.

When the name is given in small capitals, it designates that the Fellow is also a Life Member, and is entitled to the Annual Volume of Proceedings.

Baker, Marcus, U. S. Geological Survey, Washington, D. C. (30). 1882. **A**

BARKER, PROF. G. F., Univ. of Penn., Philadelphia, Pa. (13). 1875. **B C**

Barnard, Edward E., Observatory of Vanderbilt University, Nashville, Tenn. (26). 1883. **A**

Barnard, F. A. P., President Columbia College, New York, N. Y. (7). 1874. **B D I A F**

Barnes, Prof. Chas. R., 241 Columbia St., La Fayette, Ind. (33). 1885. **F**

Bartlett, Prof. Edwin J., Dartmouth College, Hanover, N. H. (28). 1883. **C**

Bartlett, John R., Commander U. S. N., Navy Dep't, Washington, D. C. (30). 1882. **E B**

Barus, Carl, Ph.D., National Museum, Washington, D. C. (33). 1887. **B**

Bassett, Homer F., Waterbury, Conn. (23). 1874. **F**

Batchelder, John M., 3 Divinity Avenue, Cambridge, Mass. (8). 1875. **B D I**

Bates, Henry Hobart, U. S. Patent Office, Washington, D. C. (33). 1887. **B A C D**

Bausch, Edward, Rochester, N. Y. (26). 1883. **A B C F**

Beal, Prof. Wm. James, Agricultural College, Ingham Co., Mich. (24). 1880. **F**

Beardsley, Prof. Arthur, Swarthmore College, Swarthmore, Del. Co., Pa. (33). 1885. **D**

Beauchamp, Rev. Wm. M., Baldwinsville, N. Y. (34). 1886. **H**

Bebb, M. S., 926 Grant Ave., Rockford, Ill. (34). 1886. **F**

Bell, Dr. Alex. Graham, Scott Circle, 1500 Rhode Island Ave., Washington, D. C. (26). 1879. **B H I**

Bell, Alex. Melville, 1525 35th St., Washington, D. C. (31). 1885. **H**

Bell, Samuel N., Manchester, N. H. (7). 1874.

Beman, Wooster W., 11 So. 5th St., Ann Arbor, Mich. (34). 1886. **A**

Benjamin, Marcus, 51 East 67th St., New York, N. Y. (27). 1887. **C**

Benjamin, Rev. Raphael, M.A., St. Clair Hotel, Cincinnati, Ohio (34). 1887. **F A B D E H I**

Bessey, Prof. Charles E., Univ. of Nebraska, Lincoln, Neb. (21). 1880. **F**

Bethune, Rev. C. J. S., Trinity College School, Pt. Hope, Ont., Can. (18). 1875. **F**

Beyer, Dr. Henry G., U. S. N., U. S. National Museum, Washington, D. C. (31). 1884. **F**

Bickmore, Prof. Albert S., American Museum of Natural History, 8th Ave. and 77th St., Central Park, New York, N. Y. (17). 1880. **H**

Billings, John S., Surgeon U. S. A., Surg. General's Office, Washington, D. C. (32). 1883. **F H**

Blackham, George E., M.D., Dunkirk, N. Y. (25). 1883. **F**

Blake, Clarence J., M.D., 226 Marlborough St., Boston, Mass. (24). 1877. **B F**

Blake, Prof. Eli W., Brown Univ., Providence, R. I. (15). 1874. **B**

Blake, Francis, Auburndale, Mass. (23). 1874. **B A**

Boardman, Mrs. William D., 88 Kenilworth St., Roxbury, Mass. (28). 1885. **E H**

Boerner, Chas. G., Vevay, Switzerland Co., Ind. (29). 1886. **A B E**

BOLTON, DR. H. CARRINGTON, University Club, New York, N. Y. (17). 1875. **C**

Bond, Geo. M., care of The Pratt & Whitney Co., Hartford, Conn. (33). 1885. **D**

Borden, Spencer, Fall River, Mass. (29). 1882. **B C I**

Boss, Prof. Lewis, Director Dudley Observ., Albany, N. Y. (26). 1878.

Bourke, John G., Capt. 3d Cavalry, U. S. A., care of Adj. Gen. U. S. A., Washington, D. C. (33). 1885. **H**

Bouvé, Thos. T., Boston Soc. Nat. Hist., Boston, Mass. (1). 1875. **E**

Bowditch, Prof. H. P., Jamaica Plain, Mass. (28). 1880. **F B H**

Bowditch, Henry I., M.D., 113 Boylston St., Boston, Mass. (2). 1875. **F H**

Bowser, Prof. E. A., Rutgers College, New Brunswick, N. J. (28). 1881.

Brace, DeWitt B., Lincoln, Neb. (35). 1887. **B**

Brackett, Prof. C. F., College of New Jersey, Princeton, N. J. (19). 1875. **B**

Brackett, Solomon H., St. Johnsbury, Vt. (29). 1884. **B A**

Branner, John C., Director of the Geological Survey of Arkansas, Little Rock, Ark. (34). 1886. **E F**

Brashear, Jno. A., Allegheny, Pa. (33). 1885. **A B D**

Brewer, Prof. Wm. H., New Haven, Conn. (20). 1875. **E F I**

Brewster, William, 61 Sparks St., Cambridge, Mass. (29). 1884. **F**

Brinton, D. G., M.D., Media, Pa. (33). 1885. **H**

Britton, N. L., Columbia College, New York, N. Y. (29). 1882. **F E**

Broadhead, Garland Carr, Pleasant Hill, Cass Co., Mo. (27). 1879. **E**

Brooks, Wm. R., Phelps, N. Y. (35). 1886. **A**

Bross, Hon. Wm., Tribune Office, Chicago, Ill. (7). 1874. **E H**

Brown, Robert, care of Yale College Observatory, New Haven, Conn. (11). 1874.

Brown, Mrs. Robert, New Haven, Conn. (17). 1874.

Brühl, Gustav, cor. John and Hopkins Sts., Cincinnati, Ohio (28). 1886. **H**

Brush, Charles F., Brush Electric Light Co., Cleveland, Ohio (35). 1886. **B**

BRUSH, PROF. GEORGE J., Yale College, New Haven, Conn. (4). 1874. **C E**

Buckhout, W. A., State College, Centre Co., Pa. (20). 1881. **F**

Burnham, S. W., 3573 Vincennes Ave., Chicago, Ill. (25). 1877. **A**

Burr, Prof. William H., Phoenixville, Chester Co., Pa. (31). 1883.

Burrill, Prof. T. J., Univ. of Illinois, Champaign, Ill. (29). 1882. **F**

Butler, A. W., Brookville, Franklin Co., Ind. (30). 1885. **F H**

Caldwell, Prof. Geo. C., Cornell University, Ithaca, N. Y. (23). 1875. **C**

Campbell, Edw. D., Box 402, Sharon, Mercer Co., Pa. (34). 1887. **C**

Canby, William M., 1101 Delaware Avenue, Wilmington, Del. (17). 1878. **F**

Carhart, Prof. Henry S., University of Michigan, Ann Arbor, Mich. (29) 1881. **B**

Carmichael, Prof. Henry, 7 Broad St., Boston, Mass. (21). 1875. **C**

Carpenter, Lieut. W. L., U. S. A., Dunkirk, N. Y. (24). 1877. **F E**
Carr, Lucien, Peabody Museum Archæology and Ethnology, Cambridge, Mass. (25). 1877. **H**
Case, Col. Theo. S., Kansas City, Mo. (27). 1883. **H B**
Chamberlin, T. C., Madison, Wis. (21). 1877. **E B F H**
Chandler, Prof. C. F., School of Mines, Columbia Coll., 50th St. cor. 4th Ave., New York, N. Y. (19). 1875. **C**
Chandler, Prof. Charles Henry, Ripon, Wis. (28). 1883. **A B**
Chandler, Seth C., jr., 16 Cragie St., Cambridge, Mass. (29). 1882. **A**
Chandler, Prof. W. H., South Bethlehem, Pa. (19). 1874. **C**
Chanute, O., Kansas City, Mo. (17). 1877. **D I**
Chapin, Dr. J. H., Meriden, Conn. (33). 1886. **E H**
Chester, Prof. Albert H., Hamilton College, Clinton, N. Y. (29). 1882. **C F**
Chickering, Prof. J. W., jr., Deaf Mute College, Washington, D. C. (22). 1877. **F I**
Chittenden, Russell H., Ph.D., New Haven, Conn. (29). 1882. **C F**
Clapp, Miss Cornelia M., Mt. Holyoke Seminary, South Hadley, Mass. (31). 1883. **F**
Clark, Alvan G., Cambridgeport, Mass. (28). 1880. **A B**
Clark, Prof. John E., Mathematics, Yale College, New Haven, Conn. (17). 1875. **A**
Clarke, Miss Cora H., Jamaica Plain, Mass. (29). 1884. **F I**
Clarke, Prof. F. W., U. S. Geological Survey, Washington, D. C. (18). 1874. **C**
Claypole, Prof. Edw. W., Buchtel Coll., Akron, Ohio (30). 1882. **E F**
Clayton, H. Helm, Readville, Mass. (34). 1887. **B**
Cloud, John W., Buffalo, N. Y. (28). 1886. **A B D**
Coffin, Prof. John H. C., U. S. Navy, Washington, D. C. (1). 1874. **A**
Coffin, Prof. Selden J., Lafayette College, Easton, Pa. (22). 1874. **A I**
Collett, Prof. John, Indianapolis, Ind. (17). 1874. **E**
Colvin, Verplanck, Supt. N. Y. State Adirondack Survey, Albany, N. Y. (28). 1880. **E**
Comstock, Prof. Geo. C., Washburn Observ., Univ. of Wisconsin, Madison, Wis. (34). 1887. **A**
Comstock, J. Henry, Cornell Univ., Ithaca, N. Y. (28). 1882. **F**
Comstock, Milton L., 641 Academy St., Galesburg, Ill. (21). 1874. **A**
Comstock, Prof. Theo. B., Prof. of Mining Engineering, Univ. of Illinois, Champaign, Ill. (24). 1877. **D E B**
Cook, Prof. A. J., Agricultural College, Mich. (24). 1880. **F**
Cook, Prof. George H., New Brunswick, N. J. (4). 1875. **E**
Cooley, Prof. Le Roy C., Vassar College, Poughkeepsie, N. Y. (19). 1880. **B C**
Cooley, Prof. Mortimer E., Univ. of Michigan, Ann Arbor, Mich. (33). 1885. **D**
Cope, Prof. Edward D., 2100 Pine St., Philadelphia, Pa. (17). 1875. **F E**
Corthell, Elmer L., 34 Nassau St., Room 709, New York, N. Y. (34). 1886. **D**
Coulter, Prof. John M., Wabash Coll., Crawfordsville, Ind. (32). 1884. **F**

Cox, Prof. Edward T., New Harmony, Ind. (19). 1874. **E**

Cox, Hon. Jacob D., Gilman Ave., Mt. Auburn, Cincinnati, Ohio (30). 1881. **F**

Coxe, Eckley B., Drifton, Luzerne Co., Pa. (23). 1879. **D E**

Crampton, Chas. A., Dept. of Agric., Washington, D. C. (36). 1887. **C**

Crandall, Prof. A. R., Lexington, Ky. (29). 1883. **E F**

Crocker, Susan E., M.D., Lawrence, Mass. (21). 1874. **E F**

Crosby, Prof. Wm. O., Boston Society of Natural History, Boston, Mass. (29). 1881. **E**

Cross, Prof. Chas. R., Mass. Institute Technology, Boston, Mass. (29). 1880. **B**

Cummings, Rev. Joseph, D.D., President Northwestern University, Evanston, Ill. (13). 1874. **I H**

Cutting, Hiram A., M.D., State Geologist, Lunenburgh, Vt. (17). 1874. **E F**

Dabney, Chas. W., jr., Ph.D., Agricultural Experiment Station, Raleigh, N. C. (30). 1882. **C B E**

Dall, Mrs. Caroline H., 1630 O St., Washington, D. C. (18). 1874. **F H**

Dall, William H., Smithsonian Institution, Washington, D. C. (18). 1874. **H F**

Dana, Edward Salisbury, New Haven, Conn. (23). 1875. **B E**

Dana, Prof. James D., New Haven, Conn. (1). 1875. **E**

Danforth, Edward, Department of Public Instruction, Elmira, N. Y. (11). 1874. **E I H A B**

Davenport, B. F., M.D., 161 Tremont St., Boston, Mass. (29). 1883. **C**

Davidson, Prof. Geo., Asst. U. S. Coast and Geodetic Survey, San Francisco, Cal. (29). 1881. **A B D**

Davis, Wm. Morris, Cambridge, Mass. (33). 1885. **E B**

Dawson, Sir William, Principal McGill College, Montreal, Can. (10). 1875. **E**

Day, David F., Buffalo, N. Y. (35). 1887. **F**

Day, F. H., M.D., Wauwatosa, Wis. (20). 1874. **E H F**

Dean, George W., P. O. Box 92, Fall River, Mass. (15). 1874. **A**

Dewey, Fred P., Ph.B., Smithsonian Institution, Washington, D. C. (30). 1886. **C E**

Diller, J. Silas, U. S. Geol. Survey, Washington, D. C. (29). 1884. **E**

Dimmock, George, Cambridge, Mass. (22). 1874. **F**

Dinwiddie, Robert, 117 W. 43d St., New York, N. Y. (1). 1874. **F**

Dodge, Charles R., Washington, D. C. (22). 1874.

Dodge, Prof. James A., University of Minnesota, Minneapolis, Minn. (29). 1884. **C E**

Dodge, J. Richards, Washington, D. C. (31). 1884. **I H**

Dolbear, A. Emerson, College Hill, Mass. (20). 1880. **B**

Doolittle, Prof. C. L., South Bethlehem, Pa. (25). 1885. **A**

Dorsey, Rev. J. Owen, Box 591, Washington, D. C. (31). 1883. **H**

Douglass, Andrew E., P. O. Box 605, New York, N. Y. (31). 1885. **H**

Dow, Capt. John M., 69 Seventh Ave., New York, N. Y. (31). 1884. **F H**

Draper, Dan'l, Ph.D., Director N. Y. Meteorological Observatory, Central Park, 64th St., Fifth Avenue, New York, N. Y. (29). 1881. **B D F A**

Drown, Prof. Thos. M., Mass. Institute Technology, Boston, Mass. (29). 1881. **C**

Du Bois, Prof. Aug. J., New Haven, Conn. (30). 1882. **A B D**

Du Bois, Patterson, Ass't Editor S.S.T., 1031 Walnut St., Philadelphia, Pa. (33). 1887. **H C I**

Dudley, Charles B., Altoona, Pa. (23). 1882. **C B D**

Dudley, P. H., 66½ Pine St., New York, N. Y. (29). 1884.

Dudley, Wm. L., Prof. of Chemistry, Vanderbilt Univ., Nashville, Tenn. (28). 1881. **C**

Dudley, Prof. Wm. R., Ithaca, N. Y. (29). 1883. **F**

Dun, Walter A., M D., 70 E. 4th St., Cincinnati, Ohio (31). 1886. **H**

Dunnington, Prof. F. P., University of Virginia, Va. (26). 1880. **C**

Dutton, Capt. C. E., U. S. Ord. Dept., Washington, D. C. (23). 1875.

Dwight, Prof. William B., Vassar College, Poughkeepsie, N. Y. (30). 1882. **E F**

Eastman, Prof. J. R., U. S. Naval Observatory, Washington, D. C. (26). 1879. **A**

Eaton, Prof. D. G., 55 Pineapple St., Brooklyn, N. Y. (19). 1874. **B E**

Eaton, Prof. James R., Liberty, Mo. (29). 1885. **C B E**

Eaton, Hon. John, President Marietta College, Marietta, Ohio (25). 1883. **I**

Eddy, Prof. H. T., Univ. of Cincinnati, Cincinnati, O. (24). 1875. **A B D**

Edison, Thos. A., Menlo Park, N. J. (27). 1878. **B**

Edmands, J. Rayner, Observatory, Cambridge, Mass. (29). 1880.

Egleston, Prof. Thomas, 35 W. Washington Square, New York, N. Y. (27). 1879. **C D E**

Eimbeck, William, U. S. C. and G. S., Washington, D. C. (17). 1874. **A B D**

Elkin, William L., Yale Coll. Observ., New Haven, Conn. (33). 1885. **A**

Elliott, Arthur H., 591 Broadway, care Anthony's Bulletin, New York, N. Y. (23). 1880. **C**

Elliott, Ezekiel B., Government Actuary, Treasury Dep't, Washington, D. C. (10). 1874. **I A B**

Ely, Theo. N., Sup't Motive Power, Penn. R. R., Altoona, Pa. (29). 1886.

Emerson, Prof. Benjamin K., Amherst, Mass. (19). 1877. **E F**

Emerson, Prof. C. F., Dartmouth Coll., Hanover, N. H. (22). 1874. **B A**

Emerton, James H., 11 St. James Ave., Boston, Mass. (18). 1875. **F**

Emery, Albert H., Stamford, Conn. (29). 1884. **D B**

Emery, Charles E., 22 Cortlandt St., New York, N. Y. (34). 1886. **D B A**

Emmons, S. F., U. S. Geol. Survey, Washington, D. C. (26). 1879. **E**

Engelmann, George J., M.D., 3003 Locust St., St. Louis, Mo. (25). 1875. **F H**

Evans, Asher B., 500 Pine St., Lockport, N. Y. (19). 1874. **A**

Fairbanks, Henry, Ph.D., St. Johnsbury, Vt. (14). 1874. **B D A**

Fairchild, Prof. H. L., Sec'y N. Y. Acad. Sciences, 102 E. 52d St., New York, N. Y. (28). 1883. **E F**

Fanning, John T., Union Depot, Minneapolis, Minn. (29). 1885. **D**

Farlow, Dr. W. G., 29 Holyoke House, Cambridge, Mass. (20). 1875. **F**

Farmer, Moses G., Eliot, Me. (9). 1875.

Farquhar, Henry, Coast Survey Office, Washington, D. C. (33). 1886. **A**

Fernald, Prof. Charles H., Amherst, Mass. (22). 1881. **F E**

Fernald, Prof. M. C., State Agric. College, Orono, Me. (22). 1883. **B A**

Fernow, Bernhard E., Chief of Forestry Division, Dep't of Agriculture, Washington, D. C. (31). 1887. **F I**

Ferrel, Wm., 1641 Broadway, Kansas City, Mo. (11). 1875. **A B**

Ficklin, Prof. Joseph, Univ. of Missouri, Columbia, Mo. (20). 1878. **A B**

Fine, Prof. Henry B., College of New Jersey, Princeton, N. J. (35). 1887. **A**

Firmstone, F., Easton, Pa. (33). **D**

Fitch, Edward H., Jefferson, Ashtabula Co., Ohio (11). 1874. **I E**

Fletcher, Miss Alice C., care Peabody Museum, Cambridge, Mass. (29). 1883. **H**

Fletcher, Dr. Robert, Surgeon General's Office, U. S. A., Washington, D. C. (29). 1881. **F H**

Flint, Albert S., U. S. Naval Observ., Washington, D. C. (30). 1887. **A**

Flint, James M., Surgeon U. S. N., Navy Dep't, Washington, D. C. (28). 1882. **F**

Foote, Dr. A. E., 1223 Belmont Ave., Philadelphia, Pa. (21). 1874. **E C**

Forbes, Prof. S. A., Univ. of Illinois, Champaign, Ill. (27). 1879. **F**

Fox, Prof. Joseph G., Lafayette College, Easton, Pa. (31). 1886. **A B D**

Foye, Prof. J. C., Lawrence Univ., Appleton, Wis. (29). 1884. **C B**

FRAZER, DR. PERSIFOR, 917 Clinton St., Philadelphia, Pa. (24). 1879. **E C**

Frazier, Prof. B. W., The Lehigh Univ., Bethlehem, Pa. (24). 1882. **E C**

Frear, Wm., State College, Centrè Co., Pa. (33). 1886. **C**

French, Prof. Thomas, jr., Ridgeway Ave., Avondale, Cincinnati, Ohio (30). 1883. **B**

Frisby, Prof. Edgar, U. S. N. Observ., Washington, D. C. (28). 1880. **A**

Fuller, Andrew S., Ridgewood, Bergen Co., N. J. (24). 1882. **F**

Fulton, Prof. Robert B., University, Miss. (21). 1887. **B A**

Gage, Simon Henry, Ithaca, N. Y. (28). 1881. **F**

Gannett, Henry, U. S. Geological Survey, Washington, D. C. (33). 1884. **E I A**

Gardiner, Rev. Frederic, D.D., Middletown, Conn. (23). 1874. **C B**

Garland, Rev. Dr. L. C., Chancellor Vanderbilt University, Nashville, Tenn. (25). 1877. **B**

Garman, Samuel, Museum Comparative Zoology, Cambridge, Mass. (20). 1874. **F E**

Gatschet, Dr. Albert S., Box 591, Washington, D. C. (30). 1882. **H**

Genth, Dr. F. A., University of Pennsylvania, Philadelphia, Pa. (24). 1875. **C E**

Gibbs, Prof. J. Willard, New Haven, Conn. (33). 1885. **B**
Gilbert, G. K., Box 591, Washington, D. C. (18). 1874. **E**
Gill, Prof. Theo., Smithsonian Institution, Washington, D. C. (17). 1874.
Gillman, Henry, Detroit, Mich. (24). 1875. **H F**
Gilman, Daniel C., President Johns Hopkins University, Baltimore, Md. (10). 1875. **E H**
Goessman, Prof. C. A., Mass. Agric. Coll., Amherst, Mass. (18). 1875. **C**
Gold, Theodore S., West Cornwall, Conn. (4). 1887. **B C**
Goldschmidt, S. A., Ph.D., 55 Broadway, New York, N. Y. (24). 1880. **C E B**
Gooch, Frank A., Yale College, New Haven, Conn. (25). 1880. **C**
Goodale, Prof. G. L., Botanic Gardens, Cambridge, Mass. (18). 1875.
Goode, G. Brown, Curator Nat'l Museum, Washington, D. C. (22). 1874.
Goodfellow, Edward, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (24). 1879. **A H**
Gould, Dr. B. A., Cambridge, Mass. (2). 1875. **A B**
Grant, Mrs. Mary J., Brookfield, Conn. (23). 1874. **A**
Gratacap, L. P., Ph.B., 77th St. and 8th Ave., New York, N. Y. (27). 1884. **C E F**
Gray, Elisha, Sc.D., Highland Park, Ill. (32). 1883. **B**
Green, Traill, M.D., Easton, Pa. (1). 1874. **C F**
Grimes, J. Stanley, Evanston, Cook Co., Ill. (17). 1874. **E H**
Grinnell, George Bird, 40 Park Row, New York, N. Y. (25). 1885. **F E**
Gulley, Prof. Frank A., Agricultural College, Oktibbeha Co., Miss. (30). 1883.

Hagen, Dr. Hermann A., Museum Comparative Zoology, Cambridge, Mass. (17). 1875. **F**
Hague, Arnold, U. S. Geol. Survey, Washington, D. C. (26). 1879.
Hale, Albert C., Ph.D., Box 65, Brooklyn, N. Y. (29). 1886. **C B**
Hale, Horatio, Clinton, Ontario, Can. (30). 1882. **H**
Hall, Prof. Asaph, U. S. Naval Observ., Washington, D. C. (25). 1877. **A**
Hall, Prof. C. W., Univ. of Minnesota, Minneapolis, Minn. (28). 1883. **E**
Hall, Prof. Edwin H., 5 Avon St., Cambridge, Mass. (29). 1881. **B**
Hall, Prof. James, Albany, N. Y. (1). 1875. **E F**
Hall, Prof. Lyman B., Haverford College, Pa. (31). 1884. **C**
Halsted, Byron D., Agricultural College, Ames, Iowa (29). 1883. **F**
Hamlin, Dr. A. C., Bangor, Me. (10). 1874. **C E H**
HANAMAN, C. E., Troy, N. Y. (19). 1883. **F**
Hardy, Prof. A. S., Dartmouth College, Hanover, N. H. (28). 1883. **A**
Harger, Oscar, 14 University Place, New Haven, Conn. (25). 1879. **F E**
HARKNESS, PROF. WILLIAM, U. S. N. Observatory, Washington, D. C. (26). 1878. **A B C D**
Harris, Uriah R., Lieutenant U. S. N., Navy Yard, Mare Island, Vallejo, Cal. (34). 1886. **A**
Harris, W. T., Lock Box 1, Concord, Mass. (27). **H I**
Hart, Edw., Ph.D., Easton, Pa. (33). 1885.

Hasbrouck, Prof. I. E., 364 Carlton Ave., Brooklyn, N. Y. (23). 1874. **D A I**

Hastings, C. S., Sheffield Scientific School of Yale College, New Haven, Conn. (25). 1878. **B**

Haupt, Prof. Lewis M., University of Pennsylvania, Philadelphia, Pa. (32). 1885. **I D E**

Haynes, Henry W., 239 Beacon St., Boston, Mass. (28). 1884. **H**

Heilprin, Prof. Angelo, Acad. Nat. Sciences, Philadelphia, Pa. (33). 1885. **E F**

Hendricks, J. E., Des Moines, Iowa (29). 1885. **A**

Hering, Rudolph, 31 Chambers St., Room 19, New York, N. Y. (33). 1885. **D E I**

Herrick, Clarence L., Granville, Ohio (31). 1884. **F E**

Hervey, Rev. A. B., Taunton, Mass. (22). 1879. **F**

Hicks, Prof. Lewis E., State University, Lincoln, Neb. (31). 1885. **E F**

Hilgard, Prof. E. W., University of California, Berkeley, Cal. (11). 1874. **C E B**

Hilgard, Prof. J. E., Washington, D. C. (4). 1874. **A**

Hill, Chas. S., care Dep't of State, Washington, D. C. (33). 1887. **A I**

Hill, Rev. Dr. Thomas, 738 Congress St., Portland, Me. (3). 1875. **A**

Himes, Prof. Charles F., Carlisle, Pa. (29). 1882. **B C**

Hitchcock, Prof. Charles H., Hanover, N. H. (11). 1874. **E**

Hitchcock, Romyn, Washington, D. C. (29). 1881. **C B**

Hobbs, A. C., Bridgeport, Conn. (28). 1886. **D**

Hodges, N. D. C., Editorial office of Science, 47 Lafayette St., New York, N. Y. (29). 1882. **B**

Hoffmann, Dr. Fred., 183 Broadway, New York, N. Y. (28). 1881. **C F**

Holden, Prof. E. S., Lick Observatory, San José, Cal. (23). 1875. **A**

Holman, Silas W., Massachusetts Institute of Technology, Boston, Mass. (31). 1883. **B**

Holmes, Dr. Oliver Wendell, 296 Beacon St., Boston, Mass. (29). 1881. **H**

Holmes, Wm. H., Bureau of Ethnology, Smithsonian Institution, Washington, D. C. (30). 1883. **H**

Horsford, Prof. E. N., Cambridge, Mass. (1). 1876. **C E**

Hosea, Lewis M., Johnston Building, Cincinnati, Ohio (30). 1883.

Hotchkiss, Major Jed., Staunton, Va. (31). 1883. **E H I**

Hough, Prof. G. W., Director Dearborn Observatory, Chicago, Ill. (15). 1874. **A**

Hovey, Rev. Horace C., 14 Park St., Bridgeport, Conn. (29). 1883. **E H**

Hoy, Philo R., M.D., 902 Main St., Racine, Wis. (17). 1875. **F H**

Hulst, Rev. Geo. D., 15 Himrod St., Brooklyn, N. Y. (29). 1887. **F**

Hunt, George, Providence, R. I. (9). 1874.

Hunt, Dr. T. Sterry, Montreal, Canada (1). 1874. **C E**

Hyatt, Prof. Alpheus, Natural History Society, Boston, Mass. (18). 1875. **E**

Hyde, Prof. E. W., Walnut Hills, Cincinnati, Ohio (25). 1881. **A**

Iddings, Joseph P., U. S. Geol. Survey, Washington, D. C. (31). 1884. **E**

James, Edmund J., Ph.D., Univ. of Pa., Philadelphia, Pa. (33). 1887. **I**
James, Prof. Jos. F., Miami Univ., Oxford, Butler Co., Ohio (30). 1882. **F E**
Jastrow, Dr. Jos., Johns Hopkins Univ., Baltimore, Md. (35). 1887. **H F**
Jayne, Horace F., 1826 Chestnut St., Philadelphia, Pa. (29). 1884. **F H**
Jeffries, B. Joy, M.D., 15 Chestnut St., Boston, Mass. (29). 1881. **F H**
Jenkins, Edw. H., New Haven, Conn. (33). 1885. **C**
Jenks, Elisha T., Middleborough, Mass. (22). 1874. **D**
Jenks, Prof. J. W. P., Middleborough, Mass. (2). 1874. **B**
Jewell, Theo. F., Commander U. S. N., Torpedo Station, Newport, R. I. (25). 1882. **B**
Jillson, Dr. B. C., 342 River Ave., E.E., Pittsburgh, Pa. (14). 1881. **E H F**
Johnson, John B., Washington Univ., St. Louis, Mo. (33). 1886. **D**
Johnson, Lawrence C., U. S. Geol. Survey, Washington, D. C. (33). 1887.
Johnson, Otis C., Ann Arbor, Mich. (34). 1886. **C**
Johnson, Prof. S. W., 54 Trumbull St., New Haven, Conn. (22). 1874. **C**
Johnson, Prof. W. W., Naval Academy, Annapolis, Md. (29). 1881. **A**
Joy, Prof. Charles A., care F. Hoffmann, Stockbridge, Mass. (8). 1879.
Julien, A. A., New York Acad. of Sciences, New York, N. Y. (24). 1875. **E C**

Kedzie, Prof. Robert C., Agricultural College, Mich. (29). 1881. **C**
Kellicott, David S., 119 Fourteenth St., Buffalo, N. Y. (31). 1883. **F**
Kendall, Prof. E. Otis, 3826 Locust St , Philadelphia, Pa. (29). 1882. **A**
Kent, William, Passaic, N. J. (26). 1881. **D I**
Kershner, Prof. Jefferson E., Lancaster City, Pa. (29). 1883. **A B**
Kimball, Arthur Lalanne, Johns Hopkins Univ., Baltimore, Md. (33). 1885. **B**
Kingsley, Prof. J. Sterling, Bloomington, Ind. (33). 1886. **F**
Kinnicutt, Leonard P., 5 Chestnut St., Worcester, Mass. (28). 1883. **C**
Kirkwood, Prof. Daniel, Bloomington, Ind. (7). 1874. **A**
Kolbe, C. W., Ph.D., 32 Longwood Ave., Cleveland, Ohio (33). 1885. **C**
Kunz, G. F., with Tiffany & Co., New York, N. Y. (29). 1883. **E H C**

Laflamme, Prof. J. C. K., Laval Univ., Quebec, Can. (29). 1887. **E B**
LaFlesche, Francis, Indian Bureau, Interior Dep't, Washington, D. C. (33). 1885. **H**
Lambert, Rev. Thomas R., D.D., Charlestown, Mass. (18). 1874.
Landreth, Prof. Olin H., Vanderbilt Univ., Nashville, Tenn. (28). 1883. **D**
Langdon, Dr. F. W., 65 West 7th St., Cincinnati, Ohio (30). 1882. **F H**
Langley, Prof. J. W., Univ. of Mich., Ann Arbor, Mich. (23). 1875. **C B**
Langley, Prof. S. P., Secretary Smithsonian Institution, Washington, D. C. (18). 1874. **A B**
Lanza, Prof. Gaetano, Mass. Institute of Technology, Boston, Mass. (29). 1882. **D A B**
Larkin, Edgar L., New Windsor, Mercer Co., Ill. (28). 1883. **A**

Lattimore, Prof. S. A., University of Rochester, Rochester, N. Y. (15). 1874. **C**

Lawrence, George N., 45 E. 21st St., New York, N. Y. (7). 1877. **F**

Lazenby, Prof. Wm. R., Columbus, Ohio (30). 1882. **B I**

LeConte, Prof. Joseph, Univ. of Cal., Berkeley, Cal. (29). 1881. **E F**

Ledoux, Albert R., Ph.D., 10 Cedar St., New York, N. Y. (26). 1881. **C**

Leeds, Prof. Albert R., Stevens Institute, Hoboken, N. J. (23). 1874. **C F**

Lehman, G. W., Ph.D., 111 S. Gay St., Baltimore, Md. (30). 1885. **C B**

Lesley, Prof. J. Peter, State Geologist of Pennsylvania, 1008 Clinton St., Philadelphia, Pa. (2). 1874. **E**

Lewis, Prof. H. Carvill, High St., Germantown, Pa. (26). 1880. **E**

Libbey, William, jr., Princeton, N. J. (29). 1887. **E F**

LILLY, GEN. WM., Mauch Chunk, Carbon Co., Pa. (28). 1882. (Patron). **F E**

Lindsley, J. Berrien, M.D., 135 North Spruce St., Nashville, Tenn. (1). 1874. **F**

Lintner, J. A., N. Y. State Entomologist, Room 27, Capitol, Albany, N. Y. (22). 1874. **F**

Litton, Abram, 2220 Eugenia St., St. Louis, Mo. (28). 1879. **C**

Lockwood, Samuel, Ph.D., Freehold, Monmouth Co., N. J. (18). 1875. **F B A**

Loomis, Prof. Elias, New Haven, Conn. (1). 1874. **A B**

Loughridge, Prof. R. H., South Carolina College, Columbia, S. C. (21). 1874. **E C**

Love, Edward G., School of Mines, Columbia College, New York, N. Y. (24). 1882. **C**

Lovering, Prof. Joseph, Harv. Univ., Cambridge, Mass. (2). 1875. **B A**

Lupton, Prof. N. T., Auburn, Ala. (17). 1874. **C**

Lyle, David Alexander, Capt. of Ordnance U. S. A., Box 2253, Boston, Mass. (28). 1880. **D**

Lyman, Prof. Chester S., 88 Trumbull St., New Haven, Conn. (4). 1875. **A**

Lyon, Dr. Henry, 34 Monument Sq., Charlestown, Mass. (18). 1874.

McAdams, Wm., Alton, Ill. (27). 1885. **E H**

McCauley, Capt. C. A. H., Ass't Q. M., U. S. A., 321 Michigan Ave., Chicago, Ill. (29). 1881.

McGee, W. J., U. S. Geol. Survey, Washington, D. C. (27). 1882. **E**

McLeod, C. H., McGill Univ., Montreal, Can. (35). 1887.

McMurtrie, William, Univ. of Illinois, Champaign, Ill. (22). 1874. **C**

McNeill, Malcolm, Princeton, N. J. (32). 1885. **A**

McRae, Hamilton S., Sup't of Schools, Marion, Ind. (20). 1874. **H I**

Mabery, Prof. C. F., Case School of Applied Science, Cleveland, Ohio (29). 1881. **C**

Macfarlane, Prof. A., Univ. of Texas, Austin, Texas (34). 1886. **B A**

Mackintosh, James B., Lehigh Univ. So. Bethlehem, Pa. (27). 1883. **C B**

Macloskie, Prof. George, College of New Jersey, Princeton, N. J. (25). 1882. **F**

Magie, Prof. William F., College of New Jersey, Princeton, N. J. (35). 1887.

Mallery, Brevet Lieut. Col. Garrick, U. S. Army, Bureau of Ethnology, Washington, D. C. (26). 1879. H

MANN, B. PICKMAN, U. S. Department of Agriculture, Washington, D. C. (22). 1874. I F

Marcy, Oliver, LL.D., Evanston, Ill. (10). 1874. E

Markoe, Prof. Geo. F. H., 29 Montrose St., Roxbury, Mass. (29). 1881.

MARSH, PROF. O. C., Yale College, New Haven, Conn. (15). 1874. F H

Martin, Prof. Daniel S., 236 West 4th St., New York, N. Y. (28). 1879. E F

Martin, Prof. H. Newell, Johns Hopkins University, Baltimore, Md. (27). 1880. F H

Martin, Miss Lillie J., High School, Indianapolis, Ind. (32). 1886. F C

Martin, Prof. Wm. J., Davidson College, N. C. (31). 1884. C E

Mason, Prof. Otis T., National Mus., Washington, D. C. (25). 1877. H

Mason, Dr. William P., Troy, N. Y. (31). 1886. C B

Maxwell, Rev. Geo. M., Wyoming, Hamilton Co., Ohio (30). 1886. H E

Mayer, Prof. A. M., South Orange, N. J. (19). 1874.

Meehan, Thomas, Germantown, Pa. (17). 1875. F

Mees, Prof. Carl Leo, Columbus, Ohio (24). 1876. B C

Mendenhall, Prof. T. C., Rose Polytechnic Inst., Terre Haute, Ind. (20). 1874. B

Merriam, C. Hart, M.D., Smith. Inst., Washington, D. C. (33). 1885. F

Merriman, C. C., Rochester, N. Y. (29). 1880. F

Merrill, Frederick J. H., Ph.B., 126 E. 60th St., New York, N. Y. (35). 1887. E

Merriman, Prof. Mansfield, Lehigh University, Bethlehem, Pa. (32). 1885. A D

Metz, Charles L., M.D., Madisonville, Hamilton Co., Ohio (30). 1885. H

Michelson, A. A., Master U. S. N., 7 Rockwell St., Cleveland, Ohio (26). 1879. B

Mills, T. Wesley, Montreal, Can. (31). 1886. F H

Minot, Dr. Charles Sedgwick, 25 Mt. Vernon St., Boston, Mass. (28). 1880. F

Minot, Francis, M.D., 65 Marlborough St., Boston, Mass. (29). 1884.

Mitchell, Miss Maria, Vassar College, Poughkeepsie, N. Y. (4). 1874.

Mixter, Prof. Wm. G., New Haven, Conn. (30). 1882. C

Moore, Prof. J. W., M.D., Lafayette College, Easton, Pa. (22). 1874. B D A

Moore, Robert, C.E., 325 Chestnut St., St. Louis, Mo. (33). 1887. D B I

Morley, Prof. Edward W., 749 Republic St., Cleveland, Ohio (18). 1876. C B E

Morong, Rev. Thomas, Ashland, Mass. (35). 1887. F

Morris, Rev. John G., Baltimore, Md. (12). 1874.

Morse, Prof. E. S., Salem, Mass. (18). 1874. F H

Morton, H., Stevens Inst. Technology, Hoboken, N. J. (18). 1875. B C

Moses, Prof. Thos. F., Urbana Univ., Urbana, Ohio (25). 1883. **H F**
Munroe, Prof. C. E., Chemist to Bureau of Ordnance, U. S. Torpedo Station, Newport, R. I. (22). 1874. **C**
Murdoch, John, Smithsonian Institution, Washington, D. C. (29). 1886. **F H**
Murdock, J. B., Lieut. U. S. N., 24 Alaska St., Roxbury, Mass. (28). 1885. **B**
Murtfeldt, Miss Mary E., Kirkwood, Mo. (27). 1881. **F**

Nason, Prof. H. B., Rensselaer Polytechnic Institute, Troy, N. Y. (18). 1874. **C E**
Nelson, Prof. A. B., Centre College, Danville, Ky. (30). 1882. **A B D**
Nelson, Prof. Edward T., Delaware, Delaware Co., Ohio (24). 1877. **E F**
Newberry, Prof. J. S., Columbia College, New York, N. Y. (5). 1875. **E F H I**
Newberry, Prof. Spencer Baird, Ithaca, N. Y. (33). 1887. **C**
Newcomb, Prof. S., Navy Dep't, Washington, D. C. (13). 1874. **A B**
Newton, Hubert A., New Haven, Conn. (6). 1874. **A**
Nichols, E. L., Ph.D., Univ. of Kansas, Lawrence, Kansas (28). 1881. **B C**
Niles, Prof. W. H., Cambridge, Mass. (16). 1874.
Nipher, Prof. F. E., Washington Univ., St. Louis, Mo. (24). 1876. **B**
Norton, Lewis M., Ph.D., Mass. Institute of Technology, Boston, Mass. (29). 1884. **C**
Noyes, Prof. Wm. A., Rose Polytechnic Inst., Terre Haute, Ind. (32). 1885. **C**
Nuttall, Mrs. Zelia, care Peabody Museum, Cambridge, Mass. (35). 1887. **H**

Oliver, Charles A., M.D., 1507 Locust St., Philadelphia, Pa. (33). 1886. **F H B**
Oliver, Prof. James E., P. O. Box 1566, Ithaca, N. Y. (7). 1875. **A B I**
Ordway, Prof. John M., Tulane Univ., New Orleans, La. (9). 1875. **C**
Orton, Prof. Edward, President Ohio Agricultural and Mechanical College, Columbus, Ohio (19). 1875. **E**
Osborn, Henry F., S.D., Princeton, N. J. (29). 1883.
Osborn, Henry Leslie, Purdue Univ., LaFayette, Ind. (29). 1887.
Osborn, Herbert, Ames, Iowa (32). 1884. **F**
Osborne, J. W., 212 Delaware Ave. N. E., Washington, D. C. (22). 1874. **D C B**
Owen, Dr. Richard, New Harmony, Ind. (20). 1874. **E**
Owens, Mrs. Mary E., 270 W. 7th St., Cincinnati, Ohio (30). 1885. **C**

Paine, Cyrus F., 242 East Ave., Rochester, N. Y. (12). 1874. **B A**
Paine, Nathaniel, Worcester, Mass. (18). 1874. **H**
Palfray, Hon. Charles W., Salem, Mass. (21). 1874.
Parke, John G., Lt. Col. Corps of Eng'rs, Bv't Maj. Gen. U. S. A., Office of Chief of Engineers, Washington, D. C. (29). 1881. **D**

PARKHURST, HENRY M., Law Stenographer, 25 Chambers St., New York, N. Y. (23). 1874. **A**

Paul, Prof. Henry M., U. S. Naval Observatory, Washington, D. C. (33) 1885. **A B**

Peabody, Cecil H., Ass't Prof. Steam Eng., Mass. Institute Technology, Boston, Mass. (32). 1887. **D**

Peabody, Seline H., Regent University of Illinois, Champaign, Ill. (17). 1885. **D B F**

Peckham, S. F., 159 Olney St., Providence, R. I. (18). 1875. **C B E**

Pedrick, Wm. R., Lawrence, Mass. (22). 1875.

Peet, Rev. Stephen D., Mendon, Ill. (24). 1881. **H**

Peirce, Benj. O., jr., Ass't Prof., Harvard College, Cambridge, Mass. (29). 1886. **A B**

Pengra, Charles P., M.D., 130 Dartmouth St., Boston, Mass. (34). 1887. **F C**

Perkins, Prof. George H., Burlington, Vt. (17). 1882. **H F E**

Peter, Dr. Robert, Kentucky Geol. Survey, Lexington, Ky. (29). 1881. **C**

Pettee, Prof. William H., Ann Arbor, Mich. (24). 1875. **E**

Philbrick, Edw. S., Brookline, Mass. (29). 1886. **D**

Phillips, A. W., New Haven, Conn. (24). 1879.

Phillips, Henry, jr., 320 So. 11th St., Philadelphia, Pa. (32). 1887. **H I**

Phippen, Geo. D., Salem, Mass. (18). 1874. **F**

Pickering, Prof. E. C., Director of Observatory, Cambridge, Mass. (18). 1875. **A B**

Pickering, William H., Harvard Observatory, Cambridge, Mass. (29). 1883. **B A**

Pilling, James C., Box 591, Washington, D. C. (28). 1882. **F H I**

Pillsbury, Prof. John H., Smith College, Northampton, Mass. (23). 1885. **F H**

Platt, Franklin, Ass't Geologist, 2nd Geol. Survey of Pa., 615 Walnut St., Philadelphia, Pa. (27). 1882. **E**

Pohlman, Dr. Julius, Buffalo, N. Y. (32). 1884. **E F**

Porter, Thos. C., LL.D., Lafayette College, Easton, Pa. (33). 1887. **F**

Powell, Major J. W., U. S. Geologist, 910 M St. N. W., Washington, D. C. (23). 1875. **E H**

Power, Prof. Frederick B., Univ. of Wis., Madison, Wis. (31). 1887. **C**

Prentiss, Prof. A. N., Cornell Univ., Ithaca, N. Y. (35). 1887. **F**

Prentiss, D. Webster, M.D., 1101 14th St., N. W., Washington, D. C. (29). 1882. **F**

Prescott, Prof. Albert B., Ann Arbor, Mich. (23). 1875. **C**

Pritchett, Henry S., Director Observatory Washington University, St. Louis, Mo. (29). 1881. **A**

Procter, John R., Dir. Kentucky Geol. Surv., Frankfort, Ky. (26). 1881.

Pulsifer, Wm. H., St. Louis, Mo. (26). 1879. **A H**

Pumpelly, Prof. Raphael, U. S. Geological Survey, Newport, R. I. (17). 1875. **E I**

Putnam, Prof. F. W., Curator Peabody Museum American Archæology and Ethnology, Cambridge, Mass. (Address as Permanent Secretary A. A. A. S., Salem, Mass.) (10). 1874. **H**

Pynchon, Rev. T. R., Pres. Trinity Coll., Hartford, Conn. (23). 1875.

Quincy, Edmund, 88 Clinton St., Boston, Mass. (11). 1874.

Rauch, Dr. John H., Chicago, Ill. (11). 1875.

Raymond, Rossiter W., 17 Burling Slip, New York, N. Y. (15). 1875. **E I**

Redfield, J. H., 216 W. Logan Square, Philadelphia, Pa. (1). 1874. **F**

Reed, E. Baynes, London, Ontario, Can. (27). 1882.

Rees, Prof. John K., Columbia College, New York, N. Y. (26). 1878. **A E B**

Remsen, Prof. Ira, Johns Hopkins Univ., Baltimore, Md. (22). 1875. **C**

Rice, John M., U. S. Naval Academy, Annapolis, Md. (25). 1881. **A D**

Rice, Prof. Wm. North, Wesleyan University, Middletown, Conn. (18). 1874. **E F**

Richards, Prof. Charles B., 313 York St., New Haven, Conn. (33). 1885. **D**

Richards, Edgar, Office of Internal Revenue, Treasury Dept., Washington, D. C. (31). 1886. **C**

Richards, Prof. Robert H., Mass. Inst. Tech., Boston, Mass. (22). 1875. **D**

Richards, Mrs. Robert H., Prof. Mass. Inst. of Tech., Boston, Mass. (23). 1878. **C**

Richardson, Clifford, Dep't of Agric., Washington, D. C. (30). 1884. **C**

Ricketts, Prof. Palmer C., Rensselaer Polytechnic Inst., Troy, N. Y. (33). 1887. **D A**

Ricketts, Pierre de Peyster, Ph.D., School of Mines, Columbia College, New York, N. Y. (26). 1880. **C D E**

RILEY, PROF. C. V., U. S. Entomologist, 1700 13th St. N. W., Washington, D. C. (17). 1874. **F H I**

Ritchie, E. S., 87 Franklin St., Boston, Mass. (10). 1877. **B**

Roberts, Prof. Isaac P., Ithaca, N. Y. (33). 1886. **I**

Robinson, Prof. S. W., Univ. of Ohio, Columbus, Ohio (30). 1883. **D B A**

Rockwell, Gen. Alfred P., Manchester, Mass. (10). 1882. **E**

Rockwell, Chas. H., Box 293, Tarrytown, N. Y. (28). 1883. **A D**

Rockwood, Prof. Charles G., jr., College of New Jersey, Princeton, N. J. (20). 1874. **A E B D**

Rogers, Fairman, 202 West Rittenhouse Square, Philadelphia, Pa. (11). 1874.

Rogers, Prof. W. A., Colby Univ., Waterville, Me. (15). 1875. **A B D**

Rominger, Dr. Carl, Ann Arbor, Mich. (21). 1879. **E**

Rood, Prof. O. N., Columbia College, New York, N. Y. (14). 1875. **B**

Rosenspitz, Dr. Alexander, Rabbi (26). 1883. **F E H**

Ross, Waldo O., 189 Devonshire St., Boston, Mass. (29). 1882.

Rowland, Prof. Henry A., Baltimore, Md. (29). 1880.

Runkle, Prof. J. D., Mass. Institute of Technology, Boston, Mass. (2). 1875. **A D**

Russell, I. C., U. S. Geological Survey, Washington, D. C. (25). 1882.

Rutherford, Lewis M., 175 Second Ave., New York, N. Y. (13). 1875.

Sadtler, Prof. Sam'l P., Univ. of Pa., Philadelphia, Pa. (22). 1875. **C**

Safford, Dr. James M., Nashville, Tenn. (6). 1875. **E C F**

Salmon, Daniel E., Dep't of Agric., Washington, D. C. (31). 1885. **F**

Sampson, Commander W. T., U. S. N., Naval Acad., Annapolis, Md. (25). 1881. **B A**

Sanborn, Jeremiah Wilson, Agric. Coll., Columbia, Mo. (31). 1886.

Sanborn, Rev. John W., Lockport, N. Y. (33). 1886. **H**

Saunders, William, London, Ontario, Canada (17). 1874. **F**

Schaeberle, J. M., Ann Arbor, Mich. (34). 1886.

Schanck, Prof. J. Stillwell, Princeton, New Jersey (4). 1882. **C B H**

Schott, Charles A., U. S. Coast and Geodetic Survey Office, Washington, D. C. (8). 1874. **A**

Schweitzer, Prof. Paul, State University of Missouri, Columbia, Mo. (24). 1877. **C B**

Scott, Prof. Wm. B., Princeton, N. J. (33). 1887. **F E**

Scovell, M. A., Director Ky. Agric. Experiment Station, Lexington, Ky. (35). 1887.

SCUDDER, SAMUEL H., Cambridge, Mass. (13). 1874. **F**

Seaman, W. H., Microscopist, 1424 11th St. N. W., Washington, D. C. (23). 1874. **C F**

Sedgwick, Prof. Wm. T., Mass. Inst. of Technology, Boston, Mass. (33). 1886. **F**

See, Horace, 1230 Spruce St., Philadelphia, Pa. (34). 1886. **D**

Seiler, Carl, M.D., 1346 Spruce St., Philadelphia, Pa. (29). 1882. **F B**

Sewall, Prof. Henry, Univ. of Mich., Ann Arbor, Mich. (34). 1885. **F**

Sharples, Stephen P., 13 Broad St., Boston, Mass. (29). 1884. **C**

Sheafer, P. W., Pottsville, Pa. (4). 1879. **E**

Sias, Solomon, M.D., Schoharie, Schoharie Co., N. Y. (10). 1874.

Sigsbee, Chas. D., Comd'r U. S. N., U. S. Naval Acad., Annapolis, Md. (28). 1882. **D E**

Sill, Hon. Elisha N., Cuyahoga Falls, Ohio (6). 1874.

Silliman, Prof. Justus M., Lafayette Coll., Easton, Pa. (19). 1874. **D E**

Skinner, Joseph J., Mass. Inst. Technology, Boston, Mass. (23). 1880. **B**

Smiley, Charles W., U. S. Fish Commission, Washington, D. C. (28). 1883. **I**

Smith, Prof. Chas. J., 35 Adelbert St., Cleveland, Ohio (32). 1885. **A B**

Smith, Edwin, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (30). 1882. **A B**

Smith, Prof. Erastus G., Beloit College, Beloit, Wis. (34). 1887. **C**

Smith, Prof. Eugene A., University of Alabama, Tuscaloosa, Ala. (20). 1877. **E C**

Smith, Prof. Francis H., University of Virginia, Charlottesville, Va. (26). 1880. **B A**

Smith, John B., National Museum, Washington, D. C. (32). 1884. **F**

SMITH, QUINTIUS C., M.D., No. 704 Congress Ave., Austin, Texas (26). 1881. **F**

Smith, Prof. S. I., Yale College, New Haven, Conn. (18). 1875. **F**

Smith, Dr. Theobald, Bureau of Animal Industry, U. S. Dep't of Agric., Washington, D. C. (35). 1887. **F**

Smock, Prof. John Conover, New York State Museum, Albany, N. Y. (23). 1879. **E**

Snow, Prof. F. H., Lawrence, Kan. (29). 1881. **F E**

Snyder, Prof. Monroe B., High School Observatory, Philadelphia, Pa. (24). 1882. **A B**

Soule, R. H., 21 Cortlandt St., New York, N. Y. (33). 1886. **D**

Spalding, Volney M., Ann Arbor, Mich. (34). 1886. **F**.

Spencer, Prof. J. William, University of Missouri, Columbia, Mo. (28). 1882. **E**

Springer, Dr. Alfred, Box 621, Cincinnati, Ohio (24). 1880. **C**

Stearns, R. E. C., care Smithsonian Institution, Washington, D. C. (18). 1874. **F**

Steiner, Dr. Lewis H., Enoch Pratt Free Library, Baltimore, Md. (7). 1874. **I**

STEPHENS, W. HUDSON, Lowville, N. Y. (18). 1874. **E H**

Sternberg, George M., Surgeon U. S. A., Johns Hopkins Univ., Baltimore, Md. (24). 1880. **F**

Stevens, W. LeConte, 170 Joralemon St., Brooklyn, N. Y. (29). 1882. **B A C**

Stevenson, James, Ass't Ethnologist, Washington, D. C. (29). 1885. **H**

Stockwell, John N., 1008 Case Avenue, Cleveland, Ohio (18). 1875. **A**

Stone, George H., Colorado Springs, Col. (29). 1882. **E F**

Stone, Mrs. Leander, 3417 Indiana Avenue, Chicago, Ill. (22). 1874. **F E**

Stone, Ormond, Director Leander McCormick Observatory, University of Virginia, Va. (24). 1876. **A**

Storrs, Henry E., Jacksonville, Ill. (20). 1874. **C E**

Story, Wm. E., Johns Hopkins Univ., Baltimore, Md. (29). 1881. **A**

Stowell, Prof. T. B., Cortland, Cortland Co., N. Y. (28). 1885. **F**

Stringham, Prof. Irving, Univ. of Cal., Berkeley, Cal. (33). 1885. **A**

Stuart, Prof. A. P. S., Lincoln, Nebraska (21). 1874. **C**

Sturtevant, E. Lewis, M.D., Geneva, N. Y. (29). 1882. **F**

Swift, Lewis, Ph.D., Rochester, N. Y. (29). 1882. **A**

Tainter, Sumner, 2020 F St. N. W., Washington, D. C. (29). 1881. **B D A**

Taylor, Thos., M.D., Dep't of Agric., Washington, D. C. (29). 1885. **F C**

Taylor, William B., Smithsonian Institution, Washington, D. C. (29). 1881. **B A**

Terry, Prof. N. M., U. S. Naval Academy, Annapolis, Md. (23). 1874. **B**

Thomas, Benj. F., Ph.D., State Univ., Columbus, Ohio (29). 1882. **B A**

Thomson, Wm., M.D., 1426 Walnut St., Philadelphia, Pa. (33). 1885. **B**

Thurston, Prof. R. H., Sibley College, Cornell University, Ithaca, N. Y. (23). 1875. **D**

Todd, Prof. David P., Director Lawrence Observatory, Amherst College, Amherst, Mass. (27). 1881. **A B D**

Todd, Prof. James E., Tabor, Fremont Co., Iowa (22). 1886. **E F**

Townshend, Prof. N. S., Ohio State Univ., Columbus, Ohio (17). 1881. **F H**

Tracy, Sam'l M., Columbia, Boone Co., Mo. (27). 1881. **F**

Trembley, J. B., M.D., 952 8th St., Oakland, Alameda Co., Cal. (17). 1880. **B F**

Trowbridge, Prof. W. P., School of Mines, Columbia College, New York, N. Y. (10). 1874. **D**

True, Fred W., U. S. National Museum, Washington, D. C. (28). 1882. **F**

Trumbull, Dr. J. Hammond, Hartford, Conn. (29). 1882. **H**

Tuttle, Prof. Albert H., State University, Columbus, Ohio (17). 1874. **F**

Uhler, Philip R., 218 W. Hoffman St., Baltimore, Md. (19). 1874. **F E**

Underwood, Prof. Lucien M., cor. Comstock Ave. and Marshall St., Syracuse, N. Y. (33). 1885. **F**

Upham, Warren, 21 Newbury St., Somerville, Mass. (25). 1880. **E**

Upton, Winslow, Brown Univ., Providence, R. I. (29). 1883. **A**

Van der Weyde, P. H., M.D., 236 Duffield St., Brooklyn, N. Y. (17). 1874. **B**

Van Dyck, Prof. Francis Cuyler, New Brunswick, N. J. (28). 1882. **B C F**

Van Vleck, Prof. John M., Middletown, Conn. (23). 1875. **A**

Vaughn, Dr. Victor C., Ann Arbor, Mich. (34). 1887. **C**

Very, Samuel W., Lieut. Comdr. U. S. N., U. S. S. Santee, Naval Acad., Annapolis, Md. (28). 1886. **A B**

Vogdes, A. W., 1st Lt. 5th Art'y U. S. A., The Military Service Inst., Governor's Island, N. Y. (32). 1885. **E F**

Wachsmuth, Charles, 111 Marietta St., Burlington, Iowa (30). 1884. **E F**

Wadsworth, M. Edward, Ph.D., Houghton, Mich. (23). 1874. **E**

Walcott, Charles D., U. S. Geological Survey, Washington, D. C. (25). 1882. **E F**

Wallace, Wm., Ansonia, Conn. (28). 1882.

WALLER, E., School of Mines, Columbia College, New York, N. Y. (23). 1874.

Walling, H. F., 98 Trowbridge St., Cambridge, Mass. (16). 1874. **E D A B**

Walmsley, W. H., 1016 Chestnut St., Philadelphia, Pa. (28). 1883. **F**

Ward, Prof. Henry A., Rochester, N. Y. (13). 1875. **F E H**

Ward, Lester F., U. S. Geological Survey, Washington, D. C. (26). 1879. **E F**

Ward, Dr. R. H., 53 Fourth St., Troy, N. Y. (17). 1874. **F B**

Warder, Prof. Robert B., Howard Univ., Washington, D. C. (19). 1881. **C B**

WARNER, JAMES D., 199 Baltic St., Brooklyn, N. Y. (18). 1874. **A B**

Warren, Cyrus M., Brookline, Mass. (29). 1882. **C**

Warren, Dr. Joseph W., 107 Boylston St., Boston, Mass. (31). 1886. **F**

Warren, Prof. S. Edward, Newton, Mass. (17). 1875. **A–I**
Watson, Sereno, Botanic Gardens, Cambridge, Mass. (22). 1875. **F**
WATSON, PROF. WM., 107 Marlborough St., Boston, Mass. (12). 1884. **A**
Wead, Prof. Charles K., Malone, N. Y. (23). 1880. **B**
Webb, Prof. J. Burkitt, Stevens Inst., Hoboken, N. J. (31). 1883. **D B A**
Webster, Prof. N. B., Park Ave., Norfolk, Va. (7). 1874. **B C E**
Wells, Daniel H., Hartford, Conn. (18). 1875. **A I**
Wendell, Oliver C., Observatory, Cambridge, Mass. (29). 1886.
Westcott, O. S., Maywood, Cook Co., Ill. (21). 1874. **H F A**
Weston, Edward, 645 High St., Newark, N. J. (33). 1887. **B C D**
Wheatland, Dr. Henry, President Essex Inst., Salem, Mass. (1). 1874.
Wheeler, Prof. C. Gilbert, 81 Clark St., Chicago, Ill. (18). 1883. **C E**
Wheeler, Orlando B., 343 N. 18th St., Philadelphia, Pa. (24). 1882. **A D**
Wheildon, W. W., Box 229, Concord, Mass. (13). 1874. **B E**
Whitaker, Channing, Box 524, Lowell, Mass. (29). 1886.
White, Prof. C. A., Le Droit Park, Washington, D. C. (17). 1875. **E F**
White, Prof. H. C., Univ. of Georgia, Athens, Ga. (29). 1885. **C**
White, Prof. I. C., Univ. of W. Va., Morgantown, W. Va. (25). 1882. **E**
Whiteaves, J. F., Geological Survey, Ottawa, Can. (31). 1887. **E F**
Whitfield, R. P., American Museum Natural History, 77th St. & 8th Avenue, New York, N. Y. (18). 1874. **E F H**
Whiting, Miss Sarah F., Wellesley College, Wellesley, Mass. (31). 1883. **B A**
Whitman, Prof. Frank P., Adelbert College, Cleveland, Ohio (33). 1885.
Wilber, G. M., Pine Plains, N. Y. (19). 1874. **F H**
Wilbur, A. B., Middletown, N. Y. (23). 1874.
Wilder, Prof. Burt G., Cornell University, Ithaca, N. Y. (22). 1875. **F**
Wiley, Prof. Harvey W., Dep't of Agric., Washington, D.C. (21). 1874. **C**
Williams, Benezette, 171 La Salle St., Chicago, Ill. (33). 1887. **D**
Williams, Charles H., M.D., 7 Otis Place, Boston, Mass. (22). 1874.
Williams, Geo. Huntington, Johns Hopkins Univ., Baltimore, Md. (33). 1886. **E**
Williams, Henry Shaler, Cornell Univ., Ithaca, N. Y. (18). 1882. **E F**
Williams, Prof. Henry W., 15 Arlington St., Boston, Mass. (11). 1874. **H F**
Williams, Prof. S. G., Cornell Univ., Ithaca, N. Y. (33). 1885. **E**
Wilson, Prof. Daniel, President University College, 117 Bloor St., Toronto, Canada (25). 1876. **H E**
Willson, Prof. Frederick N., Princeton, N. J. (33). 1887. **A D**
Wilson, H. C., U. S. Naval Observatory, Washington, D. C. (30). 1885. **A**
Wilson, Joseph M., 435 Chestnut St., Philadelphia, Pa. (33). 1886. **D**
Winchell, Prof. Alex., Ann Arbor, Mich. (3). 1875. **E**
Winchell, Prof. N. H., Univ. of Minnesota, Minneapolis, Minn. (19). 1874. **E H**
Winlock, Wm. C., U. S. N. Observ., Washington, D. C. (33). 1885. **A B**
Woerd, Chas. V., Am. Watch Co., Waltham, Mass. (29). 1881. **D A**

Wood, Prof. De Volson, Hoboken, N. J. (29). 1881.
Woodbury, C. J. H., 31 Milk St., Boston, Mass. (29). 1884. D
Woodward, Prof. Calvin M., 1761 Missouri Ave., St. Louis, Mo. (32). 1884. D A I
Woodward, R. S., care of U. S. Geol. Survey, Washington, D. C. (33). 1885. A B D
Wormley, T. G., Univ. of Pennsylvania, Philadelphia, Pa. (20). 1878.
Worthen, A. H., Springfield, Ill. (5). 1874. E
Wrampelmeier, Theo. J., San Diego, Cal. (34). 1887. C
Wright, Prof. Albert A., Oberlin College, Oberlin, Ohio (24). 1880. E F
Wright, Prof. Arthur W., Yale Coll., New Haven, Conn. (14). 1874. A B
Wright, Rev. Geo. F., Oberlin College, Oberlin, Ohio (29). 1882. E
Würtele, Rev. Louis C., Acton Vale, Province of Quebec, Can. (11). 1875. E

Young, A. V. E., Northwestern Univ., Evanston, Ill. (33). 1886. C B
Young, C. A., Prof. of Astronomy, College of New Jersey, Princeton, N. J. (18). 1874. A B D

Zentmayer, Joseph, 147 S. Fourth St., Philadelphia, Pa. (29). 1882. F

[667 FELLOWS.]

SUMMARY.—PATRONS, 3; MEMBERS, 1285; HONORARY FELLOW, 1; FELLOWS, 667.

MARCH 8, 1888. TOTAL NUMBER OF MEMBERS OF THE ASSOCIATION 1956.

DECEASED MEMBERS.

[The names of those only who are members of the Association at the *time of their decease* are included in this list. Information of the date of birth and death, to fill blanks in this list, is requested by the Permanent Secretary.]

Abbe, George W., New York, N. Y. (28). Died Sept. 25, 1879.

Abert, J. J., Washington, D. C. (1). Born in 1785. Died January 27, 1863.

Adams, C. B., Amherst, Mass. (1). Born January 11, 1814. Died Jan'y 19, 1853.

Adams, Edwin F., Charlestown, Mass. (18).

Adams, Samuel, Jacksonville, Ill. (18). Born Dec. 19, 1806. Died April 29, 1877.

Agassiz, Louis, Cambridge, Mass. (1). Born May 28, 1807. Died Dec. 14, 1873.

Ainsworth, J. G., Barry, Mass. (14).

Alexander, Stephen, Princeton, N. J. (1). Born Sept. 1, 1806. Died June 25, 1883.

Allen, Thomas, St. Louis, Mo. (27). Died April 8, 1882.

Allen, Zachariah, Providence, R. I. (1). Died March 17, 1882.

Allston, R. F. W., Georgetown, S. C. (3). Born April 21, 1801. Died April 7, 1864.

Alvord, Benjamin, Washington, D. C. (17). Died Oct. 16, 1884, at the age of 71.

Ames, M. P., Springfield, Mass. (1). Born in 1803. Died April 23, 1847.

Andrews, Ebenezer B., Lancaster, Ohio (7). Died Aug. 21, 1880, aged 59.

Anthony, Charles H., Albany, N. Y. (6). Died in 1874.

Appleton, Nathan, Boston, Mass. (1). Born Oct. 6, 1779. Died July 14, 1861.

Armstrong, John W., Fredonia, N. Y. (24).

Ashburner, Wm., San Francisco, Cal. (29). Died April 20, 1887.

Atwater, Mrs. S. T., Chicago, Ill. (17). Born Aug. 8, 1812. Died April 11, 1878.

Aufrecht, Louis, Cincinnati, Ohio (30).

Bache, Alexander D., Washington, D. C. (1). Born July 19, 1806. Died Feb. 17, 1867.

Bache, Franklin, Philadelphia, Pa. (1). Born Oct. 25, 1792. Died March 19, 1864.

Bailey, Jacob W., West Point, N. Y. (1). Born April 29, 1811. Died Feb. 26, 1857.

Baird, Spencer Fullerton, Washington, D. C. (1). Died Aug. 19, 1887.

Bardwell, F. W., Lawrence, Kan. (13). Died in 1878.
Barnard, John G., New York, N. Y. (14). Died May 14, 1882.
Barrett, Moses, Milwaukee, Wis. (21). Died in 1873.
Barry, Redmond, Melbourne, Australia (25).
Bassett, Daniel A., Los Angeles, Cal. (29). Born Dec. 8, 1819. Died May 26, 1887.
Bassnett, Thomas, Jacksonville, Fla. (8). Died Feb. 16, 1886, aged 79 years.
Bayne, Herbert A., Kingston, Ont., Can. (29). Died Aug. 1886.
Beach, J. Watson, Hartford, Conn. (23). Born Dec. 28, 1823. Died Mar. 16, 1887.
Beck, C. F., Philadelphia, Pa. (1).
Beck, Lewis C., New Brunswick, N. J. (1). Born Oct. 4, 1798. Died April 21, 1853.
Beck, T. Romeyn, Albany, N. Y. (1). Born Aug. 11, 1791. Died Nov. 19, 1855.
Beckwith, Henry C., Coleman's Station, N. Y. (29). Died July 12, 1885.
Belfrage, G. W., Clifton, Texas (29). Died Dec. 7, 1882.
Belt, Thomas, London, Eng. (27). Died Sept. 8, 1878.
Benedict, George W., Burlington, Vt. (16). Born Jan. 11, 1796. Died in 1871.
Bicknell, Edwin, Boston, Mass. (18). Born in 1830. Died March 19, 1877.
Binney, Amos, Boston, Mass. (1). Born Oct. 18, 1803. Died Feb. 1, 1847.
Binney, John, Boston, Mass. (3).
Blackie, Geo. S., Nashville, Tenn. (26).
Blair, Henry W., Washington, D. C. (26). Died Dec. 15, 1884.
Blake, Eli Whitney, New Haven, Conn. (1). Born Jan. 27, 1795. Died Aug. 18, 1886.
Blake, Homer C., New York, N. Y. (28). Born Feb. 1, 1822.
Blanding, William, ———, R. I. (1).
Blatchford, Thomas W., Troy, N. Y. (6).
Blatchley, Miss S. L., New Haven, Conn. (19). Died March 13, 1873.
Boadle, John, Haddonfield, N. J. (20). Born in 1805. Died in July, 1878.
Bomford, George, Washington, D. C. (1). Born 1780. Died March 25, 1848.
Bowles, Miss Margaretta, Columbia, Tenn. (26). Died July, 1887.
Bowron, James, South Pittsburg, Tenn. (26). Died in Dec., 1877.
Bradley, Leverette, Jersey City, N. J. (15). Died in 1875.
Braithwaite, Jos., Chambly, C. W. (11).
Briggs, Albert D., Springfield, Mass. (13). Died Feb. 20, 1881.
Briggs, Robert, Philadelphia, Pa. (29). Born May 18, 1822. Died July 24, 1882.
Brigham, Charles H., Ann Arbor, Mich. (17). Born July 27, 1820. Died in Jan., 1879.
Brown, Andrew, Natchez, Miss. (1).
Brown, Horace, Salem, Mass. (27). Died in July, 1883.

Bull, John, Washington, D. C. (31). Born Aug. 1, 1819. Died June 9, 1884.

Burbank, L. S., Woburn, Mass. (18).

Burke, Joseph Chester, Middletown, Conn. (29). Died in 1885.

Burnap, G. W., Baltimore, Md. (12). Born Nov. 30, 1802. Died Sept. 8, 1859.

Burnett, Waldo I., Boston, Mass. (1). Died July 1, 1854, aged 27.

Butler, Thomas B., Norwalk, Conn. (10). Born Aug. 22, 1806. Died June 8, 1873.

Cairns, F. A., New York, N. Y. (27). Died in 1879.

Campbell, Mrs. Mary H., Crawfordsville, Ind. (22). Died Feb. 27, 1882.

Carpenter, Thornton, Camden, S. C. (7).

Carpenter, William M., New Orleans, La. (1).

Case, Leonard, Cleveland, Ohio (15). Born June 27, 1820. Died Jan. 5, 1880.

Case, William, Cleveland, Ohio (6).

Caswell, Alexis, Providence, R. I. (2). Born Jan. 29, 1799. Died Jan. 8, 1877.

Chadbourne, Paul Ansel, Amherst, Mass. (10). Born Oct. 21, 1823. Died Feb. 23, 1883.

Chapman, N., Philadelphia, Pa. (1). Born May 28, 1780. Died July 1, 1853.

Chase, Pliny E., Haverford College, Pa. (18).

Chase, Stephen, Hanover, N. H. (2). Born in 1813. Died Aug. 5, 1851.

Chauvenet, William, St. Louis, Mo. (1). Born May 24, 1819. Died Dec. 13, 1870.

Cheesman, Louis M., Hartford, Conn. (32). Died in Jan. 1885, aged 27 yrs.

Cheney, Miss Margaret S., Jamaica Plain, Mass. (29). Died in 1882.

Clapp, Asahel, New Albany, Ind. (1). Born Oct. 5, 1792. Died Dec. 15, 1862.

Clark, Henry James, Cambridge, Mass. (13). Died July 1, 1873, aged 47.

Clark, Joseph, Cincinnati, Ohio (5).

Clark, Patrick, Rahway, N. J. (33). Died March 5, 1887.

Clarke, A. B., Holyoke, Mass. (13).

Cleaveland, C. H., Cincinnati, Ohio (9).

Cleveland, A. B., Cambridge, Mass. (2).

Coffin, James H., Easton, Pa. (1). Born Sept. 6, 1806. Died Feb. 6, 1873.

Cole, Frederick, Montreal, Can. (31). Died in 1887.

Cole, Thomas, Salem, Mass. (1). Born Dec. 24, 1779. Died June 24, 1852.

Coleman, Henry, Boston, Mass. (1).

Collins, Frederick, Washington, D. C. (28). Born Dec. 5, 1842. Died Oct. 27, 1881.

Conrad, Timothy Abbott, Philadelphia, Pa. (1). Born in August, 1803. Died August 9, 1877.

Cooke, Caleb, Salem, Mass. (18). Born Feb. 15, 1838. Died June 5, 1880.

Cooper, William, Hoboken, N. J. (9). Died in 1864.

Copes, Joseph S., New Orleans, La. (11). Born Dec. 9, 1811. Died March 1, 1885.

Corning, Erastus, Albany, N. Y. (6). Born Dec. 14, 1794. Died April 9, 1872

Costin, M. P., Fordham, N. Y. (30). Died June 8, 1884.

Couper, James Hamilton, Darien, Ga. (1). Born March 5, 1794. Died July 3, 1866.

Cramp, J. M., Wolfville, N. S. (11). Born July 25, 1796. Died Dec. 6, 1881.

Crehore, John D., Cleveland, Ohio (24).

Crocker, Charles F., Lawrence, Mass. (22). Died in July, 1881.

Crocker, Miss Lucretia, Boston, Mass. (29). Died in 1886.

Crosby, Alpheus, Salem, Mass. (10). Born Oct. 13, 1810. Died April 17, 1874.

Crosby, Thomas R., Hanover, N. H. (18). Born Oct. 22, 1816. Died March 1, 1872.

Croswell, Edwin, Albany, N. Y. (6). Born in May, 1797. Died June 13, 1871.

Crow, Wayman, St. Louis, Mo. (27). Born March 7, 1808. Died May 10, 1885.

Curry, W. F., Geneva, N. Y. (11).

Curtis, Josiah, Washington, D. C. (18). Died Aug. 1, 1883.

Dalrymple, E. A., Baltimore, Md. (11). Died Oct. 30, 1881.

Davenport, H. W., Washington, D. C. (30).

Dayton, Edwin A., Madrid, N. Y. (7). Born in 1827. Died June 24, 1873.

Dean, Amos, Albany, N.Y. (6). Born Jan. 16, 1808. Died Jan. 26, 1868.

Dearborn, George H. A. S., Roxbury, Mass. (1).

Dekay, James E., New York, N. Y. (1). Born in 1792. Died Nov. 21, 1851.

Delano, Joseph C., New Bedford, Mass. (5). Born Jan. 9, 1796. Died Oct. 16, 1886.

DeLaski, John, Carver's Harbor, Me. (18).

Devereux, J. H., Cleveland, Ohio (18). Died March 17, 1886.

Dewey, Chester, Rochester, N. Y. (1). Born Oct. 25, 1781. Died Dec. 15, 1867.

Dexter, G. M., Boston, Mass. (11).

Dillingham, W. A. P., Augusta, Me. (17).

Dimmick, L. N., Santa Barbara, Cal. (29). Died May 31, 1884.

Dixwell, Geo. B., Boston, Mass. (29). Died April, 1885.

Doggett, Mrs. Kate N., Chicago, Ill. (17). Died March 12, 1884.

Doggett, Wm. E., Chicago, Ill. (17). Born Nov. 20, 1820. Died in 1876.

Doolittle, L., Lenoxville, C. E. (11). Died in 1862.

Dorr, E. P., Buffalo, N. Y. (15). Died March 28, 1881.

Draper, Henry, New York, N. Y. (28). Died Nov. 20, 1882.

Ducatel, J. T., Baltimore, Md. (1).

Duffield, George, Detroit, Mich. (10). Born July 4, 1794. Died June 26, 1869.

Dumont, A. H., Newport, R. I. (14).

Duncan, Lucius C., New Orleans, La. (10). Died Aug. 9, 1855, aged 54.

Dunn, R. P., Providence, R. I. (14).

Eads, James Buchanan, New York, N. Y. (27). Born May 23, 1820. Died March 8, 1887.

Easton, Norman, Fall River, Mass. (14). Died Dec. 21, 1872.

Eaton, James H., Beloit, Wis. (17). Died Jan. 5, 1877.

Elsberg, Louis, New York, N. Y. (28). Died Feb. 19, 1885, aged 48 years.

Elwyn, Alfred L., Philadelphia, Pa. (1). Died March 15, 1884.

Ely, Charles Arthur, Elyria, Ohio (4).

Emerson, Geo. B., Boston, Mass. (1). Born Sept. 12, 1797. Died March 4, 1881.

Emmons, Ebenezer, Williamstown, Mass. (1). Born May 16, 1799. Died October 1, 1863.

Engelmann, George, St. Louis, Mo. (1). Born Feb. 2, 1809. Died Feb. 4, 1884.

Engstrom, A. B., Burlington, N. J. (1).

Eustis, Henry L., Cambridge, Mass. (2). Born Feb. 1, 1819. Died Jan. 11, 1885.

Everett, Edward, Boston, Mass. (2). Born April 11, 1794. Died Jan. 15, 1865.

Ewing, Thomas, Lancaster, Ohio (5). Born Dec. 28, 1789. Died Oct. 26, 1871.

Faries, R. J., Wauwatosa, Wis. (21). Died May 31, 1878.

Farquharson, Robert James, Des Moines, Iowa (24). Born July 15, 1824. Died Sept. 6, 1884.

Ferris, Isaac, New York, N. Y. (6). Born Oct. 9, 1798. Died June 16, 1873.

Feuchtwanger, Lewis, New York, N. Y. (11). Died June 25, 1876.

Fillmore, Millard, Buffalo, N. Y. (7). Born Jan. 7, 1800. Died March 8, 1874.

Fisher, Mark, Trenton, N. J. (10).

Fitch, Alexander, Hartford, Conn. (1). Born March 25, 1799. Died Jan. 20, 1859.

Fitch, O. H., Ashtabula, Ohio (7). Died Sept. 17, 1882, in his 80th year.

Forbush, E. B., Buffalo, N. Y. (15).

Force, Peter, Washington, D. C. (4). Born Nov. 26, 1790. Died Jan. 23, 1868.

Ford, A. C., Nashville, Tenn. (26).

Forshey, Caleb G., New Orleans, La. (21). Died in Aug., 1881.

Foster, John W., Chicago, Ill. (1). Born March 4, 1815. Died June 29, 1873.

Foucon, Felix, Madison, Wis. (18).

Fowle, Wm. B., Boston, Mass. (1). Born Oct. 17, 1795. Died Feb. 6, 1865.

Fox, Charles, Grosse Ile, Mich. (7).

Frazer, John F., Phila., Pa. (1). Born July 8, 1812. Died Oct. 12, 1872.

Freeman, Spencer Hedden, Cleveland, Ohio (29). Born Oct. 8, 1855. Died Feb. 2, 1886.

French, J. W., West Point, N. Y. (11).

Garber, A. P., Columbia, Pa. (29). Died Aug. 26, 1881.
Gavit, John E., New York, N. Y. (1).
Gay, Martin, Boston, Mass. (1). Died Jan. 12, 1850, aged 46.
Gibbon, J. H., Charlotte, N. C. (3).
Gillespie, W. M., Schenectady, N. Y. (10). Born in 1816. Died Jan. 1, 1868.
Gilmor, Robert, Baltimore, Md. (1).
Glazier, W. W., Key West, Fla. (29). Died Dec. 11, 1880.
Goldmark, J., New York, N. Y. (29). Died in April, 1882.
Gould, Augustus A., Boston, Mass. (11). Born April 23, 1805. Died Sept. 15, 1866.
Gould, B. A., Boston, Mass. (2). Born June 15, 1787. Died Oct. 24, 1859.
Graham, James D., Washington, D. C. (1). Born in 1799. Died Dec. 28, 1865.
Gray, Alonzo, Brooklyn, N. Y. (13). Born Feb. 21, 1808. Died March 10, 1860.
Gray, Asa, Cambridge, Mass. (1). Born Nov. 18, 1810. Died Jan. 30, 1888.
Gray, James H., Springfield, Mass. (6).
Greene, Benjamin D., Boston, Mass. (1). Died Oct. 14, 1862, aged 68.
Greene, Everett W., Madison, N. J. (10). Died in 1864.
Greene, Samuel, Woonsocket, R. I. (9). Died in 1868.
Greer, James, Dayton, Ohio (20). Died in Feb., 1874.
Griffith, Robert E., Philadelphia, Pa. (1).
Griswold, John A., Troy, N. Y. (19). Born in 1822. Died Oct. 31, 1872.
Guest, William E., Ogdensburg, N. Y. (6).
Guyot, Arnold, Princeton, N. J. (1). Born Sept. 5, 1809. Died Feb. 8, 1884.

Habel, Louis, Northfield, Vt. (34).
Hackley, Charles W., New York, N. Y. (4). Born March 9, 1809. Died January 10, 1861.
Hadley, George, Buffalo, N. Y. (6). Born June, 1813. Died Oct. 16, 1877.
Haldeman, S. S., Chickies, Pa. (1). Died Sept. 10, 1880, aged 68.
Hale, Enoch, Boston, Mass. (1). Born Jan. 29, 1790. Died Nov. 12, 1848.
Hance, Ebenezer, Fallsington P. O., Pa. (7). Died in 1876.
Harding, Myron H., Lawrenceburg, Ind. (30.) Died Sept., 1885.
Hare, Robert, Philadelphia, Pa. (1). Born Jan. 17, 1781. Died May 15, 1858.
Harlan, Joseph G., Haverford, Pa. (8).
Harlan, Richard, Philadelphia, Pa. (1).
Harris, Thaddeus W., Cambridge, Mass. (1). Born Nov. 12, 1795. Died Jan. 16, 1856.
Harrison, A. M., Plymouth, Mass. (29).
Harrison, B. F., Wallingford, Conn. (11). Died April 23, 1886.
Harrison, Jos., jr., Philadelphia, Pa. (12).
Hart, Simeon, Farmington, Conn. (1). Born Nov. 17, 1795. Died April 20, 1853.

Hartt, Charles F., Ithaca, N. Y. (18). Born in 1840. Died March 18, 1878.

Haven, Joseph, Chicago, Ill. (17). Born Jan. 4, 1816. Died May 23, 1874.

Hawes, George W., Washington, D. C. (23). Born Dec. 31, 1848. Died June 22, 1882.

Hayden, Ferdinand Vandeveer, Philadelphia, Pa. (29). Born Sept. 7, 1829. Died Dec. 22, 1887.

Hayden, Horace H., Baltimore, Md. (1). Born Oct. 13, 1768.

Hayes, George E., Buffalo, N. Y. (15).

Hayward, James, Boston, Mass. (1). Died July 27, 1866, aged 80.

Hazen, William B., Washington, D. C. (30). Born Sept. 27, 1830. Died Jan. 16, 1887.

Hedrick, Benjamin Sherwood, Washington, D. C. (19). Died Sept. 2, 1886. aged 60.

Hempstead, G. S. B., Portsmouth, Ohio (29). Died July 9, 1883, in his 89th year.

Henry, Joseph, Washington, D. C. (1). Born Dec. 17, 1797. Died May 13, 1878.

Hickox, S. V. R., Chicago, Ill. (17). Died in 1872.

Hicks, William C., New York, N. Y. (34). Died in 1885.

Hilgard, Theo. C., St. Louis, Mo. (17). Born Feb. 28, 1828. Died Mch. 5, 1875.

Hill, Walter N., Chester, Pa. (29). Born April 15, 1846. Died March 29, 1884.

Hincks, William, Toronto, C. W. (11).

Hitchcock, Edward, Amherst, Mass. (1). Born May 24, 1793. Died Feb. 27, 1864.

Hoadley, John Chipman, Boston, Mass. (29). Born Dec. 10, 1818. Died Oct. 21, 1886.

Hodgson, W. B., Savannah, Ga. (10). Born 1815.

Holbrook, John E., Charleston, S. C. (1). Born Dec. 31, 1796. Died Sept. 8, 1871.

Holman, Mrs. S. W., Boston, Mass. (29). Died May 5, 1885.

Hopkins, Albert, Williamstown, Mass. (19). Born July 14, 1807. Died May 25, 1872.

Hopkins, James G., Ogdensburg, N. Y. (10). Died in 1860.

Hopkins, T. O., Williamsville, N. Y. (10). Died in 1866.

Hopkins, Wm., Lima, N. Y. (5). Died in March, 1867.

Hoppock, A. E., Hastings-on-Hudson, N. Y. (29).

Horton, C. V. R., Chaumont, N. Y. (10). Died in 1862.

Horton, William, Craigville, N. Y. (1).

Hosford, Benj. F., Haverhill, Mass. (13). Died in 1864.

Hough, Franklin B., Lowville, N. Y. (4). Born 1822. Died June 11, 1885.

Houghton, Douglas, Detroit, Mich. (1). Born Sept. 21, 1809. Died Oct. 13, 1845.

Hovey, Edmund O., Crawfordsville, Ind. (20). Born July 15, 1801. Died March 10, 1877.

Howland, Theodore, Buffalo, N. Y. (15).

Hubbert, James, Richmond, Province of Quebec (16). Died in 1868.
Hunt, Edward B., Washington, D. C. (2). Born June 15, 1822. Died Oct. 2, 1863.
Hunt, Freeman, New York, N. Y. (11). Born March 21, 1804. Died March 2, 1858.

Ives, Moses B., Providence, R. I. (9). Died in 1857.
Ives, Thomas P., Providence, R. I. (10).

Jackson, Charles T., Boston, Mass. (1). Born June 21, 1805. Died Aug. 29, 1880.
James, Thomas Potts, Cambridge, Mass. (22). Born Sept. 1, 1803. Died Feb. 22, 1882.
Johnson, Walter R., Washington, D. C. (1). Born June 21, 1794. Died April 26, 1852.
Johnson, William Schuyler, Washington, D. C. (31). Born Sept. 20, 1859. Died Oct. 6, 1883.
Jones, Catesby A. R., Washington, D. C. (8).
Jones, Henry A., Portland, Me. (29). Died Sept. 3, 1883.
Jones, James H., Boston, Mass. (28).

Kedzie, W. K., Oberlin, Ohio (25).
Keely, George W., Waterville, Me. (1). Died in 1878.
Keep, N. C., Boston, Mass. (13). Died in March, 1875.
Kennicott, Robert, West Northfield, Ill. (12). Born Nov. 13, 1835. Died in 1866.
Kerr, Washington Caruthers, Raleigh, N. C. (10). Born May 24, 1827. Died Aug. 9, 1885.
Kidder, Henry Purkitt, Boston, Mass. (29). Born Jan. 8, 1823. Died Jan. 28, 1886.
King, Mitchell, Charleston, S. C. (3). Born June 8, 1783. Died in 1862.
Kirkpatrick, James A., Philadelphia, Pa. (7). Died June 3, 1886.
Kite, Thomas, Cincinnati, Ohio (5). Died Feb. 6, 1884.
Klippart, John H., Columbus, Ohio (17). Died October, 1878.
Knickerbocker, Charles, Chicago, Ill. (17). Died in 1873.
Knight, J. B., Philadelphia, Pa. (21). Died March 10, 1879.

Lacklan, R., Cincinnati, Ohio (11).
Lapham, Increase A., Milwaukee, Wis. (3). Born March 7, 1811. Died Sept. 14, 1875.
Larkin, Ethan Pendleton, Alfred Centre, N. Y. (33). Born Sept. 20, 1829. Died Aug. 23, 1887.
LaRoche, R., Philadelphia, Pa. (12).
Lasel, Edward, Williamstown, Mass. (1). Born Jan. 21, 1809. Died Jan. 31, 1852.
Lawford, Frederick, Montreal, Canada (11). Died in 1866.
Lawrence, Edward, Charlestown, Mass. (18). Born June, 1810. Died Oct. 17, 1885.

Lea, Isaac, Phila., Pa. (1). Born March 4, 1792. Died Dec. 8, 1886.
Le Conte, John Lawrence, Philadelphia, Pa. (1). Born May 13, 1825. Died Nov. 15, 1883.
Lederer, Baron von, Washington, D. C. (1).
Libbey, Joseph. Georgetown, D. C. (31). Died July 20, 1886.
Lieber, Oscar M., Columbia, S. C. (8). Born Sept. 8, 1830. Died June 27, 1862.
Lincklaen, Ledyard, Cazenovia, N. Y. (1). Died April 25, 1864.
Linsley, James H., Stafford, Conn. (1). Born May 5, 1787. Died Dec. 26, 1843.
Lockwood, Moses B., Providence, R. I. (9). Died in 1872.
Logan, William E., Montreal, Canada (1). Born April 23, 1798. Died June 22, 1875.
Loiseau, Emile F., Brussels, Belgium (33). Died April 30, 1886.
Loosey, Charles F., New York, N. Y. (12).
Lothrop, Joshua R., Buffalo, N. Y. (15).
Lowrie, J. R., Warriorsmark, Pa. (29). Died Dec. 10, 1885.
Lull, Edward P., Washington, D. C. (28). Born Feb. 20, 1836. Died March 5, 1887.
Lyon, Sidney S., Jeffersonville, Ind. (20). Born Aug. 4, 1808. Died June 24, 1872.

M'Conihe, Isaac, Troy, N. Y. (5).
McCutchen, A. R., Atlanta, Ga. (25). Died Nov. 21, 1887.
McFadden, Thomas, Westerville, Ohio (30). Born Nov. 9, 1825. Died Nov. 9, 1883.
McLachlan, J. S., Montreal, Can. (31).
McMahon, Mathew, Albany, N. Y. (11).
Maack, G. A., Cambridge, Mass. (18). Died in Aug., 1873.
Macfarlane, James, Towanda, Pa. (29). Died in 1885.
Mahan, Dennis H., West Point, N. Y. (9). Born April 2, 1802. Died Sept. 16, 1871.
Marler, George L., Montreal, Can. (31).
Marsh, Dexter, Greenfield, Mass. (1).
Marsh, James E., Roxbury, Mass. (10).
Martin, B. N., New York, N. Y. (23). Died Dec. 26, 1883.
Mather, William W., Columbus, Ohio (1). Born May 24, 1804. Died Feb. 27, 1859.
Maude, John B., St. Louis, Mo. (27). Died in April, 1879.
Maupin, S., Charlottesville, Va. (10).
Meade, George G., Philadelphia, Pa. (15). Born Dec. 30, 1815. Died Nov. 6, 1872.
Meek, F. B., Washington, D. C. (6). Born December 10, 1817. Died December 21, 1876.
Meigs, James Aitken, Philadelphia, Pa. (12). Born July 30, 1829. Died Nov. 9, 1879.
Minifie, William, Baltimore, Md. (12). Born in 1805. Died Oct. 24, 1880.

Mitchel, O. M., Cincinnati, Ohio (8). Born Aug. 28, 1810. Died Oct. 30, 1862.
Mitchell, William, Poughkeepsie, N. Y. (2). Died April 2, 1869, aged 76.
Mitchell, Wm. H., Florence, Ala. (17).
Morgan, Lewis H., Rochester, N. Y. (10). Born Nov. 21, 1818. Died Dec. 17, 1881.
Morgan, Mrs. Mary E., Rochester, N. Y. (31). Died in 1884.
Morris, John B., Nashville, Tenn. (26).
Morton, Samuel G., Philadelphia, Pa. (1). Born Jan. 26, 1799. Died May 15, 1851.
Monroe, Nathan, Bradford, Mass. (6). Born May 16, 1804. Died July 8, 1866.
Monroe, William, Concord, Mass. (18). Died April 27, 1877.
Mudge, Benjamin F., Manhattan, Kansas (25). Born Aug. 11, 1817. Died Nov. 21, 1879, aged 62.
Muir, William, Montreal, Can. (31). Died July, 1885.
Mussey, William H., Cincinnati, Ohio (30). Born Sept. 13, 1818. Died Aug. 1, 1882.

Newland, John, Saratoga Springs, N. Y. (28). Died Jan. 18, 1880.
Newton, E. H., Cambridge, N. Y. (1).
Nichols, Charles A., Providence, R. I. (17). Born Jan. 4, 1826. Died Oct. 20, 1877.
Nichols, William Ripley, Boston, Mass. (18). Died July 14, 1886, aged 39.
Nicholson, Thomas, New Orleans, La. (21).
Nicollett, Jean N., Washington, D. C. (1). Born July 24, 1786. Died Sept. 11, 1843.
Norton, John P., New Haven, Conn. (1). Born July 19, 1822. Died Sept. 5, 1852.
Norton, William A., New Haven, Conn. (6). Born Oct. 25, 1810. Died Sept. 21, 1883.
Noyes, J. O., New Orleans, La. (21).
Nutt, Cyrus, Bloomington, Ind. (20). Died in 1875.

Oakes, Wm., Ipswich, Mass. (1). Born July 1, 1799. Died July 31, 1848.
Ogden, Robert W., New Orleans, La. (21). Died March 24, 1878.
Ogden, William B., High Bridge, Westchester Co., N. Y. (17). Born in 1805. Died Aug. 3, 1877.
Oliver, Miss Mary E., Ithaca, N. Y. (20).
Olmsted, Alexander F., New Haven, Conn. (4). Born Dec. 20, 1822. Died May 5, 1853.
Olmsted, Denison, New Haven, Conn. (1). Born June 18, 1791. Died May 13, 1859.
Olmsted, Denison, Jr., New Haven, Conn. (1). Born Feb. 16, 1824. Died Aug. 15, 1846.
Orton, James, Poughkeepsie, N. Y. (18). Died Sept. 24, 1877.
Osbun, Isaac J., Salem, Mass. (29).
Otis, George Alexander, Washington, D. C. (10). Born Nov. 12, 1830. Died Feb. 23, 1881.

Packer, Harry E., Mauch Chunk, Pa. (30). Died Feb. 1, 1884.
Painter, Jacob, Lima, Pa. (23). Died in 1876.
Painter, Minshall, Lima, Pa. (7).
Parker, Wilbur F., West Meriden, Conn. (23). Died in 1876.
Parkman, Samuel, Boston, Mass. (1). Died Dec. 15, 1854, aged 38.
Parsons, Henry B., New York, N. Y. (30). Born in 1855. Died Aug. 21, 1885.
Payn, Charles H., Saratoga Springs, N. Y. (28). Born May 16, 1814. Died Dec. 20, 1881.
Peirce, B. O., Beverly, Mass. (18). Died Nov. 12, 1883, aged 71 years.
Peirce, Benjamin, Cambridge, Mass. (1). Born April 4, 1809. Died Oct. 6, 1880.
Perch, Bernard, Frankford, Pa. (35). Died in 1887, aged 37 years.
Perkins, George R., Utica, N. Y. (1). Born May 3, 1812. Died Aug. 22, 1876.
Perkins, Henry C., Newburyport, Mass. (18). Born Nov. 13, 1804. Died Feb. 2, 1873.
Perry, John B., Cambridge, Mass. (16). Died Oct. 3, 1872, aged 52.
Perry, M. C., New York, N. Y. (10).
Phelps, Mrs. Almira Hart Lincoln, Baltimore, Md. (13). Died July 15, 1884, in her 91st year.
Phillips, John C., Boston, Mass. (29). Died March 1, 1885, aged 46 yrs. 9 mos.
Piggot, A. Snowden, Baltimore, Md. (10).
Pim, Bedford Clapperton Trevelyan, London, Eng. (33). Died Oct., 1886, aged 60 years.
Platt, W. G., Philadelphia, Pa. (32). Died Nov., 1885.
Plumb, Ovid, Salisbury, Conn. (9).
Pope, Charles A., St. Louis, Mo. (12). Born May 15, 1818. Died July 6, 1870.
Porter, John A., New Haven, Conn. (14). Born March 15, 1822. Died Aug. 25, 1866.
Potter, Stephen H., Hamilton, Ohio (30). Born Nov. 10, 1812. Died Dec. 9, 1883.
Pourtalès, Louis François de, Cambridge, Mass. (1). Born in 1822. Died July 18, 1880.
Pruyn, John V. L., Albany, N. Y. (1). Born June 22, 1811. Died Nov. 21, 1877.
Pugh, Evan, Centre Co., Pa. (14).
Pulsifer, Sidney, Philadelphia, Pa. (21). Died March 24, 1884.
Putnam, Mrs. F. W., Cambridge, Mass. (19). Born Dec. 29, 1838. Died March 10, 1879.
Putnam, J. Duncan, Davenport, Iowa (27). Born Oct. 18, 1855. Died Dec. 10, 1881.

Read, Ezra, Terre Haute, Ind. (20). Died in 1877.
Redfield, William C., New York, N. Y. (1). Born March 26, 1789. Died Feb. 12, 1857.
Resor, Jacob, Cincinnati, Ohio (8). Died in 1871.

Robb, James, Fredericton, N. B. (4).

Robinson, Coleman T., Buffalo, N. Y. (15).

Rochester, Thomas F., Buffalo, N. Y. (35). Died May 23, 1887.

Rockwell, John A., Norwich, Conn. (10). Born August 27, 1803. Died February 10, 1861.

Roeder, F. A., Cincinnati, Ohio (30).

Rogers, Henry D., Glasgow, Scotland (1). Born 1809. Died May 29, 1866.

Rogers, James B., Philadelphia, Pa. (1). Born February 22, 1808. Died June 15, 1852.

Rogers, Robert E., Philadelphia, Pa. (18). Died Sept. 7, 1884.

Rogers, William Barton, Boston, Mass. (1). Born Dec. 7, 1804. Died May 30, 1882.

Root, Elihu, Amherst, Mass. (25). Born Sept. 14, 1845.

Sager, Abram, Ann Arbor, Mich. (6). Born December 22, 1810. Died August 6, 1877.

Sanders, Benjamin D., Wellsburg, W. Va. (19).

Schaeffer, Geo. C., Washington, D. C. (1). Died in 1873.

Schley, William, New York, N. Y. (28). Died in 1882.

Scott, Joseph, Dunham, C. E. (11). Died in 1865.

Seaman, Ezra C., Ann Arbor, Mich. (20). Born Oct. 14, 1805. Died July 17, 1879.

Senter, Harvey S., Aledo, Ill. (20). Died in 1875.

Seward, William H., Auburn, N. Y. (1). Born May 16, 1801. Died Oct. 10, 1872.

Sheppard, William, Drummondville, Province of Quebec, Can. (11). Born in 1783. Died in 1867.

Sherwin, Thomas, Dedham, Mass. (11). Born March 26, 1799. Died July 23, 1869.

Silliman, Benjamin, New Haven, Conn. (1). Born August 8, 1779. Died November 22, 1864.

Silliman, Benjamin, New Haven, Conn. (1). Born Dec. 4, 1816. Died Jan. 14, 1885.

Skinner, John B., Buffalo, N. Y. (15). Died in 1871.

Slack, J. H., Philadelphia, Pa. (12).

Smith, Charles A., St. Louis, Mo. (27). Died in 1884.

Smith, David P., Springfield, Mass. (29). Born Oct. 1, 1830. Died Dec. 26, 1880.

Smith, Mrs. Erminnie A., Jersey City, N. J. (25). Died June 9, 1886, aged 48.

Smith, J. Lawrence, Louisville, Ky. (1). Born Dec. 16, 1818. Died Oct. 12, 1883.

Smith, J. V., Cincinnati, Ohio (5).

Smith, James Y., Providence, R. I. (9). Born September 15, 1809. Died in 1876.

Smith, Lyndon A., Newark, N. J. (9). Born November 11, 1795. Died December 15, 1865.

Snell, Ebenezer S., Amherst, Mass. (2). Born October 7, 1801. Died in September, 1877.

Sparks, Jared, Cambridge, Mass. (2). Born May 10, 1819. Died March 14, 1866.

Spinzig, Charles, St. Louis, Mo. (27). Died Jan. 22, 1882.

Stearns, Josiah A., Boston, Mass. (29).

Steele, Joel Dorman, Elmira, N. Y. (33). Died May 25, 1886.

Stimpson, William, Chicago, Ill. (12). Died May 26, 1872.

Stone, Samuel, Chicago, Ill. (17). Born Dec. 6, 1798. Died May 4, 1876.

St. John, Joseph S., Albany, N. Y. (28). Died Nov. 23, 1882.

Straight, H. H., Chicago, Ill. (25). Died Nov. 17, 1886.

Sullivan, Algernon Sidney, New York, N. Y. (36). Died Dec. 4, 1887.

Sullivant, William S., Columbus, Ohio (7). Born Jan 15, 1803. Died April 30, 1873.

Sutton, George, Aurora, Ind. (20.) Died June 13, 1886.

Swain, James, Fort Dodge, Iowa (21). Born in 1816. Died in 1877.

Tallmadge, James, New York, N. Y. (1). Born Jan. 20, 1778. Died Oct. 3, 1853.

Taylor, Arthur F., Cleveland, Ohio (29). Born Dec. 10, 1853. Died June 28, 1883.

Taylor, Richard C., Philadelphia, Pa. (1). Born January 18, 1789. Died November 26, 1851.

Tenney, Sanborn, Williamstown, Mass. (17). Born in January, 1827. Died July 11, 1877.

Teschemacher, J. E., Boston, Mass. (1). Died Nov. 9, 1853, aged 63.

Thompson, A. Remsen, New York, N. Y. (1). Died in Oct., 1879.

Thompson, Alexander, Aurora, N. Y. (1).

Thompson, Charles O., Terre Haute, Ind. (29). Died in 1885.

Thompson, Zadock, Burlington, Vt. (1). Born May 23, 1796. Died Jan. 19, 1856.

Thomson, Henry R., Crawfordsville, Ind. (30). Died in 1884.

Thurber, Isaac, Providence, R. I. (9).

Tillman, Samuel D., Jersey City, N. J. (15). Died in 1875.

Tobin, Thomas W., Louisville, Ky. (30). Died Aug. 4, 1883.

Todd, Albert, St. Louis, Mo. (27). Born March 4, 1813. Died April 30, 1885.

Tolderoy, James B., Fredericton, N. B. (11).

Torrey, John, New York, N. Y. (1). Born Aug. 15, 1796. Died March 10, 1873.

Torrey, Joseph, Burlington, Vt. (2). Born Feb. 2, 1797. Died Nov. 26, 1867.

Totten, Joseph G., Washington, D. C. (1). Born August 23, 1788. Died April 22, 1864.

Townsend, Howard, Albany, N. Y. (10). Died in 1867.

Townsend, John K., Philadelphia, Pa. (1).

Townsend, Robert, Albany, N. Y. (9). Died in 1866.

Troost, Gerard, Nashville, Tenn. (1). Born March 15, 1776. Died Aug. 14, 1850.

Tuomey, Michael, Tuscaloosa, Ala. (1). Born September 29, 1805. Died March 20, 1857.

Tyler, Edward R., New Haven, Conn. (1). Born Aug. 3, 1800. Died Sept. 28, 1848.

Vancleve, John W., Dayton, Ohio (1).

Vanuxem, Lardner, Bristol, Pa. (1).

Vaux, William S., Philadelphia, Pa. (1). Born May 19, 1811. Died May 5, 1882.

Wadsworth, James S., Genesee, N. Y. (2). Born October 30, 1807. Died May 8, 1864.

Wagner, Tobias, Philadelphia, Pa. (9).

Walker, J. R., Bay Saint Louis, Miss. (19). Born Aug. 7, 1830. Died June 22, 1887.

Walker, Joseph, Oxford, N. Y. (10).

Walker, Sears C., Washington, D. C. (1). Born March 28, 1805. Died January 30, 1853.

Walker, Timothy, Cincinnati, Ohio (4). Born Dec. 1, 1802. Died Jan. 15, 1856.

Walsh, Benjamin D., Rock Island, Ill. (17).

Wanzer, Ira, Brookfield, Conn. (18). Born April 17, 1796. Died March 5, 1879.

Warnecke, Carl, Montreal, Can. (31). Died May 14, 1886.

Warren, Geo. Washington, Boston, Mass. (18). Died in 1884.

Warren, Gouverneur Kemble, Newport, R. I. (12). Died Aug. 8, 1882, in his 64th year.

Warren, John C., Boston, Mass. (1). Born Aug. 1, 1778. Died May 4, 1856.

Watertown, Charles, Wakefield, Eng. (1).

Watkins, Samuel, Nashville, Tenn. (26).

Watson, J. Craig, Ann Arbor, Mich. (13). Born Jan. 28, 1838. Died Nov. 23, 1880.

Webster, Horace B., Albany, N. Y. (1). Died Dec. 8, 1848, aged 31 years.

Webster, M. H., Albany, N. Y. (1).

Webster, J. W., Cambridge, Mass. (1). Died Aug. 30, 1850, aged 57.

Weed, Monroe, Wyoming, N. Y. (6). Died in 1867.

Welch, Mrs. G. O., Lynn, Mass. (21). Died in June, 1882.

Welsh, John, Philadelphia, Pa. (33). Died May, 1886.

Weyman, George W., Pittsburgh, Pa. (6). Born April, 1832. Died July 16, 1864.

Wheatland, Richard H., Salem, Mass. (13). Born July 6, 1830. Died Dec. 21, 1863.

Wheatley, Charles M., Phœnixville, Pa. (1). Died May 6, 1882.

Wheeler, Arthur W., Baltimore, Md. (29). Born in March, 1859. Died Jan. 6, 1881.

White, Samuel S., Philadelphia, Pa. (23). Died Dec. 30, 1879.
Whiting, Lewis E., Saratoga Springs, N. Y. (28). Born March 7, 1815. Died Aug. 2, 1882.
Whitman, Edmund B., Cambridge, Mass. (29). Died Sept. 2, 1883.
Whitman, Wm. E., Philadelphia, Pa. (23). Died in 1875.
Whitney, Asa, Philadelphia, Pa. (1). Born Dec. 1, 1791. Died June 4, 1874.
Whittlesey, Charles, Cleveland, Ohio (1). Born Oct. 5, 1808. Died Oct. 18, 1886.
Whittlesey, Charles C., St. Louis, Mo. (11). Died in 1872.
Wilder, Graham, Louisville, Ky. (30). Born July 1, 1843. Died Jan. 16, 1885.
Willard, Emma, Troy, N. Y. (15). Born Feb. 23, 1787. Died April 15, 1870.
Williams, Frank, Buffalo, N. Y. (25). Died Aug. 13, 1884.
Williamson, R. S., San Francisco, Cal. (12).
Wilson, W. C., Carlisle, Pa. (12).
Winlock, Joseph, Cambridge, Mass. (5). Born Feb. 6, 1826. Died June 11, 1875.
Woodbury, Levi, Portsmouth, N. H. (1). Born Dec. 22, 1789. Died Sept. 4, 1851.
Woodman, John S., Hanover, N. H. (11). Born in 1819. Died May 15, 1871.
Woodward, J. J., Washington, D. C. (28). Born Oct. 30, 1833. Died Aug. 17, 1884.
Wright, Elizur, Boston, Mass. (31). Born Feb. 12, 1804. Died Nov. 20, 1885.
Wright, Harrison, Wilkes Barre, Pa. (29). Born July 15, 1850. Died Feb. 20, 1885.
Wright, John, Troy, N. Y. (1).
Wyman, Jeffries, Cambridge, Mass. (1). Born Aug. 11, 1814. Died Sept. 4, 1874.

Yarnall, M., Washington, D. C. (26). Born in 1817. Died Jan. 27, 1879.
Youmans, Edward L., New York, N. Y. (6). Born June 3, 1821. Died Jan. 18, 1887.
Young, Ira, Hanover, N. H. (1). Died Sept. 14, 1858, aged 57.

ADDRESS

BY

E. S. MORSE,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

LADIES AND GENTLEMEN OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE:—

ELEVEN years ago I had the honor of reading before this association an address in which an attempt was made to show what American zoölogists had done for evolution. My reasons for selecting this subject were, first, that no general review of this nature had been made; and, second, that many of the oft-repeated examples in support of the Derivative theory were from European sources and did not carry the weight of equally important facts, the records of which were concealed in our own scientific journals. Darwin was pleased to write to me that most of the facts I had mentioned were familiar to him, but to use his own words he was amazed at their number and importance when brought together in this manner. The encouragement of his recognition has led me to select a continuation of this theme as a subject for the customary presidential address, a task which is at best a thankless if not a profitless one. Had I faintly realized, however, the increasing number and importance of the contributions made by our students on this subject, I should certainly have chosen a different theme.

Incomplete as is this record of ten years work I am compelled to present it. In the Buffalo address two marked periods in the work of the zoölogists in this country are recognized: the one period embracing the work of the topographers, the field surveyors in the science; the other period dating from the advent of Agassiz with the wonderful impulse he imparted to the study by his enthusiasm and devotion. A third period in American zoölogical science, and by far the most important awakening, dates from the

publication of Darwin's "Origin of Species." Its effect on zoölogical literature was striking. The papers were first tinged with the new doctrine, then saturated, and now, without reference to the theory, Derivation is taken for granted.

As zoölogists we are indebted to Darwin for the wide-spread public interest in our work. Before Darwin the importance of our special studies was far outweighed by the practical value placed upon science in the application of which an immediate material gain was assured. Chemistry, physics, geology were important only because a practical application of these sciences was capable of showing an immediate material return.

Agassiz, in his appeal to the state for appropriations for the great Museum at Cambridge, insisted that there were higher dividends than those of money to be looked for in endowments for zoölogical museums and these were intellectual dividends. While the force of this appeal will always remain true, the transcendent importance of the naturalist's studies from the standpoint of Darwin is widely recognized. Man now becomes an object of rigid scientific scrutiny from the new position which has shed such a flood of light upon the animals below him. His habits, behavior, the physical influences of his environment and their effects upon him, transmission of peculiarities through the laws of heredity,—all these factors are directly implicated in the burning questions and problems which agitate him to-day. Questions of labor, temperance, prison reform, distribution of charities, religious agitations are questions immediately concerning the mammal man and are now to be seriously studied from the solid standpoint of observation and experiment and not from the emotional and often incongruous attitude of the church. To a naturalist, it may seem well nigh profitless to discuss the question of evolution since the battle has been won, and if there be any discussion it is as to the relative merits and force of the various factors involved. The public, however, are greatly interested in the matter as may be seen by a renewal of the fight in the English reviews, and the agitation is still kept up by well-meaning, though ignorant advisers, who insist that science has not yet accepted the doctrine; and great church organizations meet to condemn and expel their teachers of science from certain schools of learning because their teachings are imbued with the heresy.

Dr. Asa Gray,[1] in his discriminating biographical memoir of

Darwin, says in regard to the "Doctrine of Descent" "it is an advance from which it is evidently impossible to recede. As has been said of the theory of the Conservation of Energy, so of this: 'The proof of this great generalization, like that of all other generalizations, lies mainly in the fact that the evidence in its favor is continually augmenting, while that against it is continually diminishing, as the progress of science reveals to us more and more the workings of the universe.'" Let us examine then the evidences, trivial as well as important, that have been recorded by American zoölogists within the past ten years in support of the Derivative theory.

Without further apology for the very imperfect character of this survey, let me at once begin by calling attention first to the testimony regarding the variation in habits and evidences of reasoning power in animals. The establishment of individual variation in mental powers, change in habits, etc., lies at the foundation of Darwinism as furnishing material for selective action. There is no group of animals which exceeds the birds in varied and suggestive material for the evolutionist. It is a significant fact that the birds, which appeared to Cuvier and his contemporaries a closed type, a group that seemed to fulfil the ideal conception of a class archetype, as compared with other groups which had their open as well as obscure relationships, should be of all groups the one that first yielded its exclusive characteristics. In fact there is no group in which the barriers have been so completely demolished as in this apparently distinct and isolated class. An attentive and patient study of the birds has established almost every point defined by Darwin in his theory of natural selection. One has only to recall the marked reptilian affinities as shown in their embryological and paleontological history. Besides all these structural relationships the birds possess as a group remarkable and striking illustrations of variation in color, size, marking, nesting, albinism, melanism, moulting, migration, song, geographical variation, sexual selection, secondary sexual characters, protective coloring; and in their habits show surprising mechanical cunning and ingenuity, curious and inexplicable freaks, parental affection, hybridity,—indeed the student need go no farther than the birds to establish every principle of the Derivative theory.

The many observations on the nesting habits of birds would form a curious chapter as illustrating the individual peculiarities of these creatures.

Dr. A. S. Packard[2] records the fact, as related to him by Mr. Wyatt, of wild geese nesting in large cotton-wood trees on Snake river, west of the Rocky mountains, and Doctor Coues in his "Birds of the Northwest" says wild geese "nest in various parts of the Upper Missouri and Yellowstone regions in trees." Mr. H. W. Turner[3] observes a robin nesting on the ground. The late Dr. T. M. Brewer[4] points out some very curious "Variations in the Nests of the same Species of Birds." He not only observes individual variation in nest structure, but shows that in different regions of the country birds of the same species build different kinds of nests, and in reflecting on these peculiarities he is led to say "If we cannot understand what it can be that stimulates an *Empidonax* in Staten island to build a pensile nest, while its fellow in Indiana builds one like a deep cup and surrounded with thorns, and another group in Pennsylvania put theirs on an exposed tree top, and so flat that the eggs seem liable to roll out, we must see that some cause, hidden to us, is gradually effecting changes that sooner or later may become universal in the species, though which it is to be we may not be able to imagine."

Mr. J. A. Allen,[5] in writing on the inadequate theory of birds' nests, shows grave and important exceptions to Wallace's theory, though he subscribes heartily to his philosophy of birds' nests. He expresses surprise that closely allied species of birds should oftentimes build divers kinds of nests, overlooking the fact that even closely allied varieties of man build entirely unlike houses.

Mr. F. H. Knowlton[6] records a cliff swallow appropriating, for the construction of its own nest, pellets of mud which were being brought by another swallow. Also the curious fact that a number of swallows were observed busily engaged in sealing up a nest in which one of their comrades lay dead. Among the curious traits of birds, Mr. H. B. Bailey[7] communicates some new ones observed in the red-headed woodpecker by Mr. Agersborg of Dakota territory. This gentleman had observed one of these birds wedging grasshoppers in a large crack of an old oak post. Nearly a hundred were stored away in this manner, the bird afterwards feeding at leisure on the supply. This parallels the habit of the California woodpecker storing acorns in holes in the tree and subsequently feeding on the fully developed larvæ within the seed.

Mr. O. P. Hay,[8] in a late number of the Auk, has an interesting paper on the red-headed woodpecker as a hoarder, showing that the bird makes accumulations of beech nuts, pounding them be-

tween the shingles of a roof, wedging them into crevices and storing them in cavities in trees.

The plausible suggestion made by Darwin as to the agency of aquatic birds in the wide dispersal of fresh-water mollusks, was singularly confirmed several years after by Mr. Arthur F. Gray shooting a duck which had clinging to one of its toes a fresh-water mussel. Dr. J. W. Fewkes[9] has recently recorded the shooting of a duck in Sebec, Maine, which was in like manner transporting a fresh-water mussel. The same bird had been observed several days before with this curious companion clinging to its foot, and had the duck been migrating at the time it might have transported the mussel many hundreds of miles. In this connection it would be an interesting inquiry as to how far the similarity observed in north temperate and circumpolar animals is due to the annual migration of birds north and south.

Mr. William Brewster [10] notes some interesting features in the habits of a young Kittiwake gull of the St. Lawrence. He brought home a young one, its mate having died of thirst, the other one surviving through the accidental discovery that the bird drank only salt water! Both the birds obstinately refused to drink fresh water. Observations on this bird by Prof. A. Hyatt showed how slowly and timidly it acquired the art of swimming and flying. The bird when first forced to fly was thrown into the air and to the surprise of Professor Hyatt flew with great rapidity and precision, circling about the house and through the apple trees, and, finally, flew near him several times in the greatest agitation till he caught the bird which was completely exhausted. For a long time the bird went through this manœuvre, showing that while he knew how to fly it could not alight, though it finally acquired this faculty. Prof. L. A. Lee[11] records a remarkable attack made on him by a marsh hawk, and Mr. Abbott M. Frazer[12] tells of a tame crow deliberately standing on an ant hill and permitting the ants to remove the parasites from its feathers. In this connection a paper by Mr. Joseph F. James [13] should be read in which he shows by a number of arguments that animals not only present a reasoning faculty, but that this faculty has been the result of slow evolution.

Mr. Xenos Clark,[13a] in an exceedingly interesting article on the music of animals and particularly the music of birds, concludes by saying there is "a theory for the origin of melody, whether

human or extra-human, which, besides the usual basis of physiological acoustics, employs the law of modified, inherited, selected and adapted structure, *i. e.*, the law of evolution."

Mr. Ruthven Deane [14] records cases of albinism and melanism in a great many families of birds, and Mr. N. C. Brown [15] shows the variable abundance of birds at the same locality in different years. In this connection it will be of interest to read Dr. L. P. Gratacap's [16] paper entitled "Zoic Maxima, or Periods of Numerical Variations in Animals."

The behavior of wild birds when kept in confinement and the attempts made in domesticating them have always furnished an interesting field for study. The curious freaks and impulses which they often betray, the changes they show under the new conditions, indicate in some measure the plasticity of their organization.

Hon. John D. Caton,[17] in an interesting paper on "Unnatural Attachments among Animals," records a curious fondness shown by a crane for a number of pigs, and in another paper on the "Wild Turkey and its Domestication"[18] this writer has made some valuable records of the successive changes which take place in the bird during this process; changes in color during which the more conspicuous features of protective coloring are lost; changes in habit in which is seen the undoing or relaxing of those features which indicate constant vigilance, from carrying itself in a semi-erect attitude, perching on the tallest trees, covering up the eggs carefully with leaves when off the nest, etc., to moving in an horizontal attitude, perching near the ground, covering the eggs but slightly, or carelessly, etc., and losing that wildness which characterizes the bird in its wild state. At the breeding season, however, the females became wild again, but this was a feature too deeply implanted to show modification in the time allotted to Mr. Caton's experiment. The same writer[19] has also observed in the Hawaiian Islands the effects of reversion to a wild state of different kinds of domestic animals which have from time to time been carried there. Among other animals he was fortunate enough to observe the undoing stages in the domestic turkey and the assumption of those features which characterize the wild bird.

A great many facts illustrating the plainest features of natural selection, protective coloring, mimicry, etc., have been recorded in our journals from time to time. A brief allusion may be made to a few of these.

Prof. Samuel F. Clarke [20] notices a pronounced case of natural selection,— a case which must often occur in nature. He kept in large glass jars masses of eggs of Amblystoma. As soon as these eggs began to hatch he found it difficult to provide the young with suitable food, and yet they seemed to thrive. On examination many of them were seen to be engaged in nibbling the branchia of others, and as they increased in size they were seen to swallow the weaker individuals bodily and hence grow with increased rapidity. "Here then," he says, "was a very interesting case of natural selection by survival of the fittest. All the weaker individuals being destroyed and actually aiding the stronger ones by serving them as food until they could pass through their changes and escape to other regions where food was more abundant." Prof. B. G. Wilder has recorded a similar condition of things in a species of spider where the young spiders within the case enclosing the eggs were feeding on the weaker ones. Prof. Henry L. Osborn [21] observes a curious case of mimicry at Beaufort in the coloring of a species of Ovulum which frequents a species of Leptogorgia. The Ovulum was yellow in color on the yellow variety of this sea fan, and purple when living on the purple variety. Dr. R. E. C. Stearns [22] has made some interesting notes on protective coloring in Phrynosomæ. Having collected these horned lizards (or toads as they are commonly called) in Central California, he has noticed that if the ground region they frequent is yellowish, the lizards are without exception of that color; if ashen grey, then that color is simulated, and this, without exception. Further than this he is "led to believe that a sufficient number of living specimens will show a similar protective factor, in degree of development of the scale imbrications, tubercles so called, and horns—or, in brief, in the sculpture aspect as related to the surface texture of the ground which forms the local habitat of these forms." Dr. A. S. Packard [23] has observed the partiality of white butterflies for white flowers. He notices the European cabbage butterfly, which is white, go directly to the white aster and rarely visit the golden rod, while the yellow sulphur butterfly visits the yellow flowers of the golden rod oftener than those of the aster. The same author [24] also observed a harmless Egerian moth which deceived the sharp eye of a trained entomologist by its resemblance to a wasp, and asks why a bird may not be equally deceived. Miss Sarah P. Monks [25] observed a case of mimetic coloring in tadpoles, their tails precisely resembling the leaves of an aquatic plant, Ludovidgia.

Miss Mary E. Murtfeldt [26] having noticed that the butterfly, *Pyrameis hunteri*, always deposited its eggs on the plant Antennaria, she was surprised to find a number of larvæ of this butterfly on Artemisia. The customary plant being rare in the immediate vicinity, the butterfly had been misled by the surface resemblance of the white cottony leaves of the Artemisia to those of the accustomed food plant. In this case the larvæ all died.

An unquestionable fact has been finally established by recent methods of observation on the habits of insects and other animals, and that is that individuals of the same species vary in intelligence: that they are not automata; that they are not impelled by a blind instinct to perform certain acts with unerring accuracy, but on the contrary that they vary and often greatly vary in their ability to provide for their young, in their skill to secure sufficient food, in their wit to avoid danger,—in other words, they make blunders and mistakes and involve their progeny and even their colony in ruin. This individual variation in intelligence is brought out very clearly by a patient series of observations made by Drs. G. W. and E. G. Peckham [27] on the special senses of wasps. They not only repeated many of the experiments of Sir John Lubbock but many new and ingenious experiments were devised. Their studies were for the purpose of investigating the mental power, sense of hearing, color, direction, memory, emotion, power of communication, general intelligence, etc. An interesting result of their painstaking work was the determination of individual differences as to the faculty of memory and power of distinguishing color and direction. This kind of study of the habits of insects has brought to light features of the most surprising character. The remarkable studies of Sir John Lubbock, Dr. Moggridge and others in Europe have been paralleled in this country not only by the observations above quoted, but notably by the labors of Rev. H. C. McCook [28] in his studies of the American ants and spiders. In various papers published in the Proceedings of the Philadelphia Academy of Natural Sciences and in the American Naturalist, he has shown many extraordinary and curious features in the life histories of these animals. The great variety and extent of his work must be my excuse for not referring to it in detail.

Prof. G. F. Atkinson,[29] in studying a new species of trap-door spider, confirms the observations of others as to the creature deliberately attaching fragments of moss to the lid of its nest in order to conceal its position. Dr. Thomas Meehan [30] describes a

hornet that was gifted with great intelligence. He saw this insect struggling with a large locust in unsuccessful attempts to fly away with it. After several fruitless efforts to fly up from the ground with his victim he finally dragged it fully thirty feet to a tree, to the top of which he laboriously ascended, still clinging to his burden, and having attained this elevated position he flew off in a horizontal direction with the locust. Dr. Meehan truly says "There was more than instinct in this act, there was reasoning on certain facts and judgment accordingly and the insect's judgment had proved correct."

A curious case of circumspection in ants is recorded by Dr. Joseph Leidy.[31] In an empty house he observed some ants feeding on crumbs of bread left by the workman. He at once placed pieces of bread in the different rooms in the house only to find them the next day covered with ants, which he destroyed by causing them to fall into a dish of turpentine. After a few days the ants no longer visited the bread and he supposed they had been exterminated. A few days after, however, he observed a number of ants in the attic feeding on the body of a dead fly. He immediately got a lot of grasshoppers and distributed their bodies in all the rooms, only to find that they were soon covered with ants, which he destroyed as before. This treat continued attractive for a few days only, when the ants abandoned the food. In brief he tried meat, cake and various other articles in turn; the ants for a while frequenting these snares only to learn the danger involved and finally avoided them.

The gradual dispersion of species in recent times is of great interest, and careful records should be made of the facts as observed and a collection of large numbers of individuals made, in order to compare them with specimens of the same species in future years, to ascertain the variation which may have taken place and the tendency of that variation. A number of observations have been published within the last ten years showing new areas of distribution. *Littorina litorea*, which has been creeping along the coast since 1869, as recorded by Gray, Verrill and others, has now reached the southern side of Long Island Sound as observed by Mr. Henry Prime.[32] *Lioplax sub-carinata*, an Ohio river species, has been found in the Hudson river at Catskill landing. *Limax maximus*, first found at Newport, R. I., by Mr. Powel, has since been found at Cambridge, Mass., by Professor Hyatt. *Bythinia*

tentaculata, first recorded from Oswego, N. Y., by Rev. W. M. Beauchamp,[33] is reported as having been found at Burlington, Vt., by G. H. Hudson. In the Mohawk river is a thriving community of this species, the first having been placed there by Dr. James Lewis.

Dr. R. E. C. Stearns,[34] in commenting on the occurrence of *Mya arenaria* in San Francisco Bay, states that the first record of the species in California was made by Dr. Newcomb in 1874. Within a few years it has increased in great numbers, furnishing a new food supply for the people. The evidence that it is a recent introduction is seen in the fact that so large and conspicuous a species could not have escaped the eye of the collector. No trace of it has ever been found in the numerous shellheaps of California, though it is found on the Asiatic coast, from Kamtchatka to the southernmost limits of Japan. Dr. Stearns believes it to have been imported with the oyster transplanted from the Atlantic coast. From large numbers of the shells that I measured, the low index would show that it came from some southern point on the Atlantic coast.

The delicate balance of conditions between organisms, whether it be between individuals of the same species or between widely separated groups, is an important feature in the question of survival. Prof. S. A. Forbes,[35] in a thoughtful study of certain species of Entomostraca in Lake Michigan and the surrounding waters, calls attention to the important part played by these minute crustaceans, showing how they furnish almost the entire food for young fishes, larger crustaceans and even insect larvæ. He writes: "Mollusca, one would say, could afford to be indifferent to them, since they neither eat them nor are eaten by them, nor seem to come in contact with them anywhere, through any of their habits or necessities. But for this very reason these two classes afford an excellent illustration of the stringent system of reactions by which an assemblage of even the most diverse and seemingly independent organisms is held together. . . . . If there were no entomostraca for young fishes to eat, there would be very few fishes indeed to feed upon mollusca, and that class would flourish almost without restraint; while, on the other hand, if there were no mollusca for the support of adult fishes, entomostraca would be relieved from a considerable part of the drain upon their numbers, and would multiply accordingly." He is much struck with the fact that in the

larger bodies of water, the species of entomostraca show an inferior development in numbers, size and robustness, and in reproductive power. Their smaller number and size are doubtless due to the relative scarcity of food. "The difference of reproductive energy, as shown by the much smaller egg-masses borne by the lacustrine species, depends upon the vastly greater destruction to which the paludinal crustacea are subjected. Many of the latter occupy waters liable to be exhausted by drought, with a consequent enormous waste of entomostracan life. The opportunity for reproduction is here greatly limited — in some situations to early spring alone — and the chances for destruction of the summer eggs in the dry and often dusty soil are so numerous that only the most prolific species can maintain themselves under such conditions.

"Further, the marshes and shallower lakes are the favorite breeding grounds of fishes, which migrate to them in spawning time, if possible, and it is from the entomostraca found here that most young fishes get their earliest food supplies—a danger from which the deep-water species are measurably free. Not only is a high reproductive power therefore rendered unnecessary among the latter by their freedom from many dangers to which the shallow-water species are exposed, but in view of the relatively small amount of food available for them, a high rate of multiplication would be a positive injury, and could result only in wholesale starvation."

The effect of birds on insect life has engaged the attention of the same author.[36] His inquiry was to ascertain whether birds originated any oscillations in the numerical proportion of insects upon which they feed. Many interesting facts are given which space forbids quoting.

A number of contributions have been made on the influence of environment and on geographical variation, to some of which reference must be made. Prof. Alpheus Hyatt[37] bears unequivocal testimony to the Derivative theory and recognizes clearly the influence of external surroundings in a memoir on the cephalopods, when in stating the law of organic equivalence he says: "The action of physical changes takes effect upon the irritable organism, which necessarily responds to external stimulants by an internal reaction or effort. This action from within upon the parts of the organism modifies their hereditary forms by the production of new growths or changes which are, therefore, adapted to the conditions of the habitat or the physical agents and forces from which they directly

or indirectly originate;" or, slightly changing this interpretation in accordance with the same facts, each individual is more or less susceptible to the action of physical influences and those which respond most quickly to these influences come more promptly in harmony with their environment which is natural selection, pure and simple.

Mr. Charles Morris,[38] in a series of papers on "Organic Physics" and the "Polar Organization of Animals," presents many new and suggestive thoughts on the physico-chemical action in life and development. He concludes that "there are inherent in the germ energies and tendencies, chemical, molecular, or whatever we choose to call them, adapted to the complete unfoldment of the typical form; but, as appears evident, their operation can be checked by influences from external nature. There is a struggle between these contact influences and the innate organic tendencies."

Under geographical variation many interesting facts have been added since Professor Baird, Dr. Allen and Mr. Ridgway published their capital discoveries, calling attention to the variations observed in birds and mammals coincident with their latitudinal range. William Bartram, grandnephew of the famous botanist John Bartram, alludes to the effect of climate in modifying species. In speaking of birds he says: "the different soil and situation of the country may have contributed in some measure in forming and establishing the difference in size and qualities betwixt them."

Dr. J. A. Allen[39] shows marked geographical variation among North American mammals in respect to size. He shows that "1. The maximum physical development of the individual is attained when the conditions of environment are most favorable to the life of the species. 2. The largest species of a group (genus, sub-family, or family, as the case may be) are found when the group to which they severally belong reaches its highest development, or when it has what may be termed its centre of distribution. 3. The most typical or most generalized representatives of a group are found also near the centre of distribution, outlying forms being generally more or less aberrant or specialized." In the study of the eggs of birds of the same species, north and south, Dr. Allen shows that in the south the eggs are less in number and smaller in size.[40] Mr. Robert Ridgway[41] calls attention to the geographical variation observed in Dendrœca.

The same author,[42] in a discussion of a paper by Salvin in

the Transactions of the Zoölogical Society of London, on the relationships between the birds of Guadalupe and the mainland, refers to the present genesis of species, and points to the increase in size of the bill and feet, the shorter tail and wings and darker colors, as characterizing them.

Dr. E. C. Coues,[43] in his studies regarding geographical variation in color among North American Insectivorous mammals, says: "My studies up to the present go to show a very interesting parallelism with the state of the case I have determined for other small mammals, notably the mice and gophers, and which my friend Mr. Allen has admirably brought out in his studies of the squirrels. In some cases I find almost identical effects of climatic, or other conditions upon the shrews and the mice of particular localities, by which they both acquire the same *facies loci*. Present indications are that the normal variability of the shrews in size, shape and color is not less than has been determined to hold good in various other families of mammals." In this memoir Dr. Coues has verified a curious fact first pointed out by Professor Baird, of the modifications of the premolar dentition which the western species collectively, as compared with the eastern, have undergone; "A striking peculiarity of all the western species, no matter how diverse in other respects, is to have the 'third premolar' decidedly smaller than the 'fourth', while in all the species east of the Rocky Mountains (with one possible exception) the same tooth is as large as, or larger than, the other. Of the fact there is no question; it may be observed in an instant, and is unmistakable. Its significance is another thing. Some of the western species are scarcely distinguishable if at all from their respective eastern analogues, except by this character, and they all show it."

Prof. A. Hyatt[44] finds in sponges geographical variation in color, referring to similar features in birds as recorded by Baird and others.

Prof. David S. Jordan,[45] in a paper on the distribution of fresh-water fishes, presents a concise series of propositions which govern these animals in the United States. They all point to the action and importance of physical conditions as governing distribution. Space will permit only the quoting of the last proposition, which is a summing up of his conclusions: "The distribution of fresh-water fishes is dependent on (*a*) fresh-water communication; on (*b*) character of stream, that is, of water, as to purity,

depth, rapidity, vegetable growth, etc.; on (*c*) the character of the river bed, as to size, condition of bottom, etc.; on (*d*) climate, as determined by latitude and by elevation above the sea; and finally on (*e*) various unknown factors arising from the nature or the past history of the species in question, or from the geological history of the rivers."

Dr. James Lewis[46] has observed a not unlike condition of things in the distribution of the fresh-water mussels of Ohio and Alabama. By a series of tables he calls attention to what he believes is the occurrence of identical and equivalent species in the two systems of drainage and suggests that, owing to the number of varieties characterizing the *Unionidæ* they may be identical. This author[47] has also studied the genus *Io* and its habits and notices its variation coincident with latitude and temperature.

Dr. R. E. C. Stearns,[48] in a paper on the circumpolar distribution of certain fresh-water mussels and the identity of certain species, unites many hitherto recognized species of *Anodonta*. Dr. J. G. Cooper,[49] in a study of the fossil and sub-fossil land shells of the United States, sees the strongest evidence in support of the idea that the older ones are the direct ancestors of certain forms living to-day.

Mr. R. P. Whitfield [50] read a paper before the Boston Society of Natural History, showing changes produced in *Limnæa megasoma* when kept in an aquarium. Having at the outset three specimens, two of them finally died and from the remaining one eggs were produced, presumably unimpregnated. These eggs hatched, and from these the next year came a second generation, which in turn produced a third generation the following year. The animal of *Limnæa* is hermaphrodite. Nevertheless besides diminished size in the shell it was observed that the male parts had disappeared and the liver had become considerably reduced in size. He shows that a diœcious species had in a short time become monœcious as a result of the new physical conditions of life in the constricted quarters of an aquarium.

An instructive paper by Dr. W. D. Hartman,[51] on the genus *Partula* of the Hawaiian Islands, shows in the most convincing manner the effect of environment in modifying the species. He finds a common occurrence of hybrids among certain forms, the result of the union of proximate species. This hybridization occurring even between arboreal and ground species, Dr. Hartman states "that

gravid females are often washed by heavy rains from a favored position to drier levels, where after a few generations the progeny become depauperated, and so stunted in size as to be mistaken for distinct species." Dr. W. H. Dall,[52] in some general considerations regarding the environment of the deep-sea mollusks as compared with the shallow-water and littoral forms, shows how much the littoral forms have to contend with in the struggle for existence as compared with the deep-sea forms, and the delicate sculpture and extreme fragility of many of the shells occurring in the deeper abysses of the sea are to be explained on the ground of their habitat. Dr. Carl F. Gissler[53] has presented some interesting evidences of the effect of chemico-physical influences in the evolution of the branchipod crustaceans.

The effect of mechanical strains as producing like morphological effects has been treated in a masterly way by Dr. John A. Ryder.[54] He cites the vertebral axes of turtles and extinct armadillos, also the sacra of birds and mammals, and says "These observed coincidences, it is believed, are neither accidental, nor designed by an active cause external to these organisms or their cosmic environment. I would rather believe that the structures, so far as they have been evolved in parallel or similar ways, are the results of like forces conditioning growth and nutrition in definite modes and determinate directions. The manner of incidence of the modifying forces being in all cases determined by the voluntary actions of the organisms, the actions in turn are determined by the degree of intelligence of the animal manifesting them."

In considering the "Laws of Digital Reduction"[55] Doctor Ryder gives a concise presentation of the various groups of animals, showing in each the line of mechanical strain in the extremities and its correlation with the increased development of those digits bearing this strain, and the consequent reduction or atrophy of those digits out of this line. These considerations led him to the following conclusions:

I. "That the mechanical force used in locomotion during the struggle for existence has determined the digits which are now performing the pedal function in such groups as have undergone digital reduction.

II. That where the distribution of mechanical strains has been alike upon all the digits of the manus or pes, or both, they have remained in a state of approximate uniformity of development.

III. It is held that these views are Lamarkian and not Darwinian; that is, that they more especially take cognizance of mechanical force as a mutating factor in evolution, in accordance with the doctrine of the correlation of forces."

Doctor Ryder further says "It seems a most convincing proof of the doctrine of descent to find man an instance of the same kind of specialization determined by the manner of the distribution of strains as is so often found among the lower groups, such as the horses, sloths, jumping mice and even-toed ungulates."

In another memoir[56] Doctor Ryder considers the mechanical motion in forming and modifying teeth. Considering first the simplest form of movement in the mammal's jaw, opening and closing, without fore and aft or lateral movement, he shows the successive changes going on coincident with the more complex movements of the jaw, and that the enamel foldings, ridges, crests, etc., have apparently been modified in conformity with the ways in which the force used in mastication was exerted.

Prof. A. Hyatt,[57] in an exhaustive study of the Planorbis of Steinheim, shows among other things the effect of gravitation as accounting for the form of the mollusk shell, citing examples from all the classes and even drawing examples from other subkingdoms to support his views.

Prof. E. D. Cope,[58] in a memoir on Archæsthetism, considers the hypothesis of use and effort, the office of consciousness, etc. He attempts to show that consciousness is primitive and a cause of evolution. He sustains his thesis by a series of arguments which, if not beyond my grasp, would be too extensive to present here. I can only repeat the regret I expressed in the Buffalo address: namely, that neither Professor Cope nor Professor Hyatt has yet been induced to present to the public an illustrated and simple outline of their theories. Such a demonstration, I am sure, would be acceptable not only to the public but to many scientific students as well. While these two eminent naturalists believe fully in the Derivative theory they insist that Darwin's theory is inadequate to explain many of the phenomena and facts which they encounter in their studies. Darwin has distinctly said in his first edition of the "Origin of Species," "I am convinced that natural selection has been the main but not the exclusive means of modification;" and in his sixth edition of the same work, in quoting these words, he laments that he is still misunderstood on this point. The theory of acceleration and retardation of these authors is, if I under-

stand it rightly, a very plain case of natural selection. It was inevitable that those individuals that matured the quickest were better prepared to defend themselves, were quicker in the field, were able to give their offspring an earlier start in the season, were in every way more fitted to survive than those which matured later. It is assumed that this is a law when, to my mind, it seems the simplest result of natural selection. Instead of overriding it, it is only a conspicuous result and proof of it.

A parallel case may be seen in the increase in size of the brain in the vertebrates, and conspicuously in the higher vertebrates, since their first appearance in geological history. The individual brain clearly varies in size and it does not require a great effort to perceive how in the long run the greater brain survives in the complex struggle for existence. Associated with the greater development, parts that were freely used for locomotion before are now compelled to perform additional service, and through the law of use and effort, which all admit as an important factor, organs are modified in structure, the anterior portion of the body assumes a new aspect; and it was on the character of these parts and aspects that Professor Dana was led to formulate his comprehensive and ingenious principle of Cephalization. It is a result and not a cause. And so I believe, though with great deference to Cope and Hyatt, that the laws of acceleration and retardation, exact parallelisms, inexact parallelisms and still more inexact parallelisms, and many other laws and theories advanced by these gentlemen, are not causes but effects, to be explained by the doctrine of natural selection and survival of the fittest.

The connecting links and intermediate forms which the skeptical public so hungrily demand are continually being discovered. Great gaps are being closed up rapidly, but the records of this work being published in the journals of our scientific societies are hidden from the public eye as much as if they had been published in Coptic. So rapidly have these missing links been established that the general zoölogist finds it difficult to keep up with the progress made in this direction. He can hardly realize the completion of so many branches of the genealogical tree.

Professor Cope,[59] who has accomplished so much in this direction, says: "Those who have, during the last ten years, devoted themselves to this study have been rewarded by the discovery of the course of development of many lines of animals, so that it is now

possible to show the kind of changes in structure which have resulted in the species of animals with which we are familiar as living on the surface of the earth at the present time. Not that this continent has given us the parentage of all forms of animal life, or all forms of animals with skeletons, or vertebræ, but it has given us many of them. To take the vertebrata, we have obtained the long-since extinct ancestor of the very lowest vertebrates. Then we have discovered the ancestor of the true fishes. We have the ancestor of all the reptiles, of the birds, and of the mammals. If we consider the mammals, or milk-givers, separately, we have traced up a great many lines to their points of departure from very primitive things. Thus we have obtained the genealogical trees of the deer, the camels, the musk, the horse, the tapir, and the rhinoceros, of the cats and dogs, of the lemurs and monkeys, and have important evidence as to the origin of man."

In 1874 he predicted that the ancestor of all the mammals would be a five-toed, flat-footed walker with tubercular molar teeth, or in exact language a pentadactyle, plantigrade bunodont. Seven years after he obtained evidences that such a type of mammals abounded in North America during the early Eocene Tertiary period. Prof. Cope,[60] in his phylogeny of the camels, shows a remarkable parallel to that of the horse, both forms appearing in the lower Eocene. Mr. Eugene N. S. Ringueberg[61] believes he has found in a thin layer of limestone at Gasport, N. Y., a deposit in which a number of forms of Brachiopods seem to present the intermediate stages between certain brachiopods common to the Clinton and the group of rocks immediately above. While the majority of species in this deposit belong to the Niagara, there are among the fossils met with, three species of brachiopods which were supposed to have passed out of existence with the Clinton. He finds in this bed thirty-two forms peculiar to the Niagara, eleven common to Niagara and Clinton, three belonging to the Clinton and two characteristic forms of the transition group. Many of these show intermediate characters.

Prof. H. S. Williams,[62] in his paleontological studies of the life history of *Spirifer lævis*, in which he traces the ancestral line of this creature, says: "Whatever theoretical description we may give to species, here are, in the first place, an abundance of individual organisms whose remains are found in the upper Silurian rocks of Europe, Great Britain and America, presenting a few clearly marked distinctive characters, which are found variously developed in the

individual forms, but so grading in the various varieties as to cause careful naturalists to associate them as varieties of a single species."

Dr. C. A. White,[63] in his comparisons of the fresh-water mussels and associated mollusks of the Mesozoic and Cenozoic periods with living species, expresses his belief that the present Unios of North America, particularly those forms allied to *Unio clavus*, have come down in an unbroken line from the Jurassic and possibly from earlier times. He shows that thus far all the fossil Unios have been obtained from lacustrine deposits, none of these beds being distinctly fluviatile. He furthermore calls attention to the fact that "these lacustrine formations are of very great extent in western North America, and, without doubt, the lakes in which they were deposited were caused by encircling bands of rising land during the elevation of the continent. These great land-locked waters were at first brackish, but finally became, and for a long time remained, fresh, continuing so until their final desiccation." From this commingling of salt and fresh water he justly assumes that many modifications arose in the forms of Unios subjected to these influences and hence has resulted a variety of forms which have gone on continually widening to the present day.

Prof. A. G. Wetherby,[64] in a paper on the geographical distribution of certain fresh-water mollusca and the possible cause of their variation, shows the paucity of forms of Unionidæ on the Pacific and Atlantic coasts as compared to the richness and profusion of those forms in the central portion of the continents. He remarks also on the absence of the family Strepotomidæ, east of the Alleghanies. He assumes that the first fresh-water forms were lacustrine. He points out the well-known geological fact of large inland enclosures and their subsequent drainage, and shows the vicissitudes which must have been encountered by species in the variety of physical conditions implied by these changes. In this connection I may be permitted to call attention to the fact that at a meeting of this Association, at Hartford, in 1874, I made a communication on the origin of the North American Unionidæ in which I urged some of the points made by Dr. White and Professor Wetherby.*

*The following is a brief abstract which was published in the Hartford Courant August, 1874. "Mr. Morse in explaining the origin of the North American Unionidæ did not pretend to point out the absolute line of descent in these forms, but wished to call attention to some curious features in the possible derivation of the fresh-water families of Mollusks from cognate genera living in salt water. It is observed, first, that the

Dr. Thomas H. Streets,[65] in studying the immature plumage of the North American shrikes, was much struck with the close resemblance between the plumage of the young of *Sula cyanops* and the adult plumage of another species. Recalling a generalization made by Darwin that "when the young differs in color from the adult, and the colors of the former are not, as far as we can see, of any special service, they may generally be attributed, like various embryological structures, to the retention by the young of the characters of an early progenitor." He then shows the gradation between the several species of shrikes from this standpoint and traces their descent from a common ancestor.

Prof. S. A. Forbes,[66] in a study of the "Blind Cave Fish and their Allies," is led to review the conclusions reached by Prof. F. W. Putnam in his interesting papers on the subject. Professor Putnam brought forth a number of arguments which seemed to him to militate against the views urged by evolutionists that their peculiar characters were adaptive and the result of their cave life. He was led to the conclusion that the absence of light had not brought about the atrophy of the eyes, the development of special sense organs, and the bleaching of the skin. In referring to another cave fish, Chologaster, with eyes fully developed, it was urged that the argument in regard to eyeless fishes could have no weight. In response to this it was answered that possibly Chologaster had not been subjected to subterranean influences long enough to be affected, and this objection was anticipated by urging that we have no right to assume that Chologaster is a more recent inhabitant of the caves, until proven.

The discovery of another species of Chologaster, taken from a spring at the base of a limestone cliff in Illinois, has given Professor Forbes an opportunity to make careful comparisons with the cave Chologaster. He says in regard to it "The most important and

few families of fresh-water mollusks are intimately related to those forms which live in the sea between high- and low-water mark, and those which can withstand the influence of brackish water. He cited certain families of fresh-water mollusks which are so closely related to tidal forms as hardly to be distinguished from them. . . . . In explaining the immense number of species of fresh-water mussels in America compared to the very few forms in Europe, we might look to an explanation of this feature in the past geological history of the two continents.

In Europe there have been no great inland seas, while in America its past history shows the enclosing of large tracts of water in which freshening from brackish water went on, and while many forms succumbed to these changed conditions, only those forms survived which resemble certain littoral species. And with the curious modifications that must have taken place in these changed conditions, one gets a possible explanation of the great variety of mollusks in our western rivers."

interesting peculiarity of this species indicates a more advanced stage of adaptation to a subterranean life than that of its congeners." Referring to Professor Putnam's arguments, Professor Forbes says that "the discovery of a species of Chologaster, which frequents external waters, of an immediate subterranean origin, supplies all needed proof that the genus either has a shorter subterranean history than Amblyopsis, or, at any rate, has remained less closely confined to subterranean situations; and that in either case the occurrence of eyes, partial absence of sensory papillæ and persistence in color, are thus accounted for consistently with the doctrine of 'descent with modification.'" In this connection it may be of interest to read the curious fact recorded by Mr. S. H. Trowbridge [67] of the discovery in the Missouri river of a shovel-nosed sturgeon which had the skin growing over the eyes, completely inclosing them. Dr. S. H. Scudder, [68] in a memoir read before the National Academy, brings forward evidence to show that ordinal features among insects were not differentiated in Palæozoic times, but that "all Palæozoic insects belonged to a single order which, enlarging its scope as outlined by Goldenberg, we may call Palæodictyoptera; in other words, the palæozoic insect was a generalized Hexapod, or more particularly a generalized Heterometabolon." In a memoir on the earliest winged insects of America embracing a reëxamination of "The Devonian Insects of New Brunswick" published by the author, Dr. Scudder replies to some sharp criticisms and objections made by Dr. Hagen and pertinently says, "That there is no evidence—but the contrary—that Dr. Hagen in his investigations uses the 'theory of descent' as a working hypothesis, without which no one studying any group of animals in the period of its rise and most rapid evolution can expect to do otherwise than stumble and wander astray. To refuse it is to merit failure."

Prof. J. S. Kingsley, [69] in his study of Limulus, regards it is an Arachnid, but states that its ancestors take us back to a time when the distinctions between the Crustacea and Arachnida were far less marked than now.

Dr. A. S. Packard,[70] in a paper on the "Genealogy of the Insects," shows by means of a "genealogical tree" the descent of the class from the Thysanura, with some hypothetical creature not unlike Scolopendrella, as the probable stem-form of the Hexapods. It is through the resemblance the larvæ of the different orders of in-

sects bear to various members of the Thysanura that this scheme is justified. It may not be out of place to say here that the use of the "genealogical tree," in suggesting the probable line of descent of various allied groups, has been severely condemned by some as leading to no practical good in classification. It seems to me, however, the only clear scheme for the proper working out of the ascertained or hypothetical relationships of animals; it is thought-exciting, its very attitude provokes studious inquiry and suggestive inferences. It may be called the modern tree of knowledge.

The modern genealogical tree as used by the biological student (and as well by the ethnologist, philologist and others) is a graphic diagram of the relationships between groups as understood by the projector, and, as such, is a most commendable and useful method with which to illustrate his meaning. With additional knowledge one can see, at a glance, the points that need strengthening, and he can pare, prune, or even graft new fruits on the old stock, or if it is rotten at the trunk, cut it down altogether. These trees have always been in vogue with the older naturalists, only, in the old style of arboriculture, the trunk was always kept stiffly vertical while the branches were bent down and trained horizontally, being flimsily attached to the main stem by printers' devices of long and short brackets. In this attitude it reminded one of the dwarfed and deformed trees of the Chinese and very properly typified the dwarfed and deformed way of looking at classification.

Never was the provisional use of a genealogical tree more completely justified than in a memoir by Dr. Alexander Agassiz [71] on the "Connection between Cretaceous and Echinid Faunæ." He certainly speaks in no uncertain terms when in considering the Spatangoids of the chalk he says, "They lead us directly through the Palæostominæ and the Collyritidæ to the Ananchytidæ which have persisted to the present day," and other relationships of the same nature are repeatedly urged as would not only justify the use of the genealogical diagram against which he so strongly inveighed in his admirable address before this Association at the Boston meeting, but had he adopted this method a much clearer view of the very points he wished to emphasize would have been afforded his readers.

It was the strictures of Agassiz above referred to that led Prof. W. K. Brooks [72] to write a paper on the subject of "Speculative

Zoölogy" in which he most earnestly and ably defends the use of genealogical diagrams and justly says, "If phylogenetic speculations retard science, speculations upon homology must do the same thing, and the only way to avoid danger will be to stick to facts, and, stripping our science of all that renders it worthy of thinking men, to become mere observing machines."

Since 1876 Professor Marsh and Professor Cope have in various journals and Government publications presented the results of their discoveries of the past vertebrate life of North America. The General Government has published the two great monographs of Professor Marsh on the Dinocerata, an extinct order of gigantic mammals, and the Odontornithes, an order of extinct toothed birds, as well as Professor Cope's great volume on the Tertiary Vertebrata besides other memoirs by the same authors. Space will forbid more than a passing allusion to the varied and remarkable additions to our knowledge of extinct vertebrate life made by these naturalists.

Had a moiety of the work accomplished by these investigators been known to Geoffroy St. Hilaire the theory of descent would have been established long before Darwin, though to Darwin and Wallace belongs the full credit of defining the true cause. Leidy, Marsh and Cope have not only brought to light a great number of curious beasts, many of them of gigantic and unique proportions, but forms revealing in their structure the solution of many morphological puzzles and throwing light on the derivation of many obscure parts.

The discovery in the western tertiaries of multitudes of huge and monstrous mammals and, earlier still, of gigantic and equally monstrous reptiles, naturally led at once to an inquiry as to the cause of their extinction. "Nothing can be more astonishing," says Prof. Joseph LeConte,[73] "than the abundance, variety and prodigious size of Reptiles in America up to the very close of the Cretaceous, and the complete absence of all the grander and more characteristic forms in the lowest Tertiary; unless, indeed, it be the correlative fact of the complete absence of mammals in the Cretaceous and their appearance in great numbers and variety in the lowest Tertiary. . . . " The wave of reptilian evolution had just risen to its crest, and perhaps was ready to break, when it was met and overwhelmed by the rising wave of mammalian Evolution." In this paper of LeConte's, which is entitled "On

Critical Periods in the History of the Earth and their Relation to Evolution: and on the Quaternary as such a Period," may be found an excellent rejoinder of Prof. Clarence King's lecture before the Sheffield Scientific School on the subject of Catastrophism and Evolution.

Among the most interesting discoveries connected with these creatures is the determination by Professor Marsh[74] that these early mammals, birds and reptiles had brains of diminutive proportions. He says in regard to the order Dinocerata, a group of gigantic mammals whose remains have been found in the tertiary deposits of the Rocky Mountain region, that they are the most remarkable of the many remarkable forms brought to light. The brain of these creatures was remarkable for its diminutive proportion. So small indeed was the brain of *Dinoceras mirabile* that it could "apparently have been drawn through the neural canal of all the presacral vertebræ." In alluding to the successive disappearance of the large brutes, the cause is not difficult to find: "The small brain, highly specialized characters, and huge bulk, rendered them incapable of adapting themselves to new conditions, and a change of surroundings brought extinction. The existing Proboscidians must soon disappear, for similar reasons. Smaller mammals, with larger brains, and more plastic structure, readily adapt themselves to their environment, and survive, or even send off new and vigorous lines. The Dinocerata with their very diminutive brain, fixed characters, and massive frames, flourished as long as the conditions were especially favorable, but, with the first geological change, they perished, and left no descendants." Professor Marsh says that the brain of Dinoceras was in fact the most reptilian brain in any known mammal.

Professor Cope[75] in describing the brain of Coryphodon from the deposits of New Mexico, says: "The large size of the middle brain and olfactory lobes gives the brain as much the appearance of that of a lizard as of a mammal." This is one of the lowest mammalian brains known. There are others from the lower Eocene with equally low brains as Arctocyon of Gervais and Uintatherium of Marsh. Cope believes that the type of brain of these early creatures is so distinct as to necessitate the erection of a third sub-class of equal rank with the groups Gyrencephala and Lycencephala which he would define as the Protencephala. He shows their approximation to reptiles.

Cope[76] refers to Gratiolet as showing that a great development of the olfactory is a character of an inferior type; in fact, the more we ascend into paleontological antiquity, the more we find that the olfactory lobes display a greater development in comparison with the cerebral hemispheres. Dr. B. G. Wilder[77] has shown that in the lamprey the only part which can be regarded as a cerebral hemisphere lies laterad of the olfactory lobe. In Dipnoi he finds that the cerebral outgrowth is ventrad. In another paper[78] he says: "In either of these directions in which what may be regarded as the special organ of the mind is projected among these low or generalized forms, there would seem to be mechanical obstacles to any considerable expansion; but dorsally there is opportunity for comparatively unlimited extension, and it is in this direction that the hemispheres begin to develop in the Amphibia and attain such enormous growth in Birds and Mammals." How far the small brain and presumably stolid intellects brought about the extinction of the huge tertiary mammals may be better understood by the suggestions offered by Prof. A. E. Verrill[79] in a lecture at Yale College entitled "Facts Illustrative of the Darwinian Theory." He shows what an important factor parental instinct is in the evolution of species. He regards the lack of parental care "as one of the probable causes, though usually overlooked, of the extinction of many of the large and powerful reptiles of the mesozoic age and of the large mammals of the tertiary." He says: "The very small size of the brain and its low organization in these early animals are now well known, and we are justified in believing that their intelligence or sagacity was correspondingly low. They were doubtless stupid and sluggish in their habits, but probably had great powers of active and passive resistance against correspondingly stupid carnivorous species. But unless the helpless young were protected by their parents, they would quickly have been destroyed; and such species might, in this way, have been rapidly exterminated whenever they came in contact with new forms of carnivorous animals, having the instinct to destroy the new-born young of mammals, and the eggs and young of oviparous reptiles. Thus it would have come about, that the more intelligent forms, by the development of the parental instinct for the active protection of their young against their enemies, would have survived longest, and therefore would have transmitted this instinct, with other correlated cerebral developments, to their descendants."

Prof. John Fiske, in his Cosmic Philosophy, arrived at a similar conclusion in regard to early man. He showed that when variations in intelligence became more important than variations in physical structure, then they were seized upon to the relative exclusion of the latter.

The derivative theory has not only clearly revealed the fact that animals have been derived from preëxisting forms, but it shows even more clearly that organs have been evolved as well. It is difficult in a general review of this nature to separate clearly the two classes of facts.

Professor Cope [80] has traced the genesis of the quadritubercular tooth in the mammals of the present day. He finds that the type of the superior molar tooth of the mammals of the Puerco epoch was triangular or tritubercular, that is, with two external and one internal tubercle. Of forty-one species of mammals of this epoch all but four of them had this type of tooth. He finds that this tooth exists to-day only in the insectivorous and carnivorous marsupials. In brief he shows a gradual change taking place from the early primitive type of tooth in the gradual development of another tubercle. The same author,[81] in defining the characters of an ancient order of mammals, the Amblypoda, says they are the most generalized order of hoofed mammals, being intermediate in the structure of their limbs and feet between the Proboscidia, the Perissodactyla and Artiodactyla, which fact together with the small size of the brain places them in antecedent relation to the latter, in a systematic sense, connecting them with the lower mammals with small and smooth brains still in existence; and in a phylogenetic sense since they precede the other orders in time, they stand in the relation of ancestors.

Professor Cope,[82] in a paper read before this Association on the "Classification of the Ungulata," gives special attention to the arrangement and character of the carpal and tarsal bones. He shows "that the weaker structure of the carpus and tarsus appears first in time; that the stronger structure appeared first in the posterior limbs, and that the interlocking structure has greatly multiplied, while the linear has dwindled and mostly disappeared. Here is a direct connection between mechanical excellence and survival."

In the light of Mr. Caldwell's unquestionable determination of the oviparous character of that curious mammal, the duck-bill

mole, associated with its known reptilian bearings as deduced from its skeleton and other features, the deductions of Professor Cope [83] regarding the "Relations between the Theromorphous Reptiles and the Monotreme Mammalia" are of great interest.

In the Theromorpha are two divisions, one of which, the Pelycosauria, is limited to the Permian, and of one of this group he makes the following comparisons: "1. The relations and number of the bones of the posterior foot are those of the Mammalia much more than those of the Reptilia. 2. The relations of the astragalus and calcaneum to each other are as in the Monotreme *Platypus anatinus*. 3. The articulation of the fibula with both calcaneum and astragalus is as in the Monotreme order of mammals."

In brief he shows the affinity of this reptile to be with the monotremes, and that the affinities are very important in the light of Mr. Caldwell's researches, and the further fact that the development of the egg is meroblastic confirms, so to speak, the reptilian affinities of the monotremes.

Here then are a series of observations by different observers from different standpoints, all telling the same story. Osteologists have long ago pointed out the reptilian affinities of the monotremes from the character of the skeleton. The anatomists in like manner have insisted upon certain reptilian characters as well as avian characters from its internal structure. A trained zoölogist now studies it on the ground and finds it laying true eggs, a fact that had been insisted upon several times in the present century. More significant still, the study of these eggs shows that they go through a reptilian mode of development. And now the paleontologist brings to light the remains of a reptile from the Permian rocks and again establishes the same relations.

In this connection the examination by Dr. Henry C. Chapman [84] of a fœtal kangaroo and its membranes is of interest. The fœtus he examined was fourteen days old. He states that it had no true placenta and says "If the parts in question have been truthfully described and correctly interpreted, as partly bridging over the gap between the placental and non-placental vertebrates, they supply exactly what the theory of evolution demands and furnish, therefore, one more proof of the truth of that doctrine."

To those who have already been startled by the memoir of Dr. W. Baldwin Spencer on the presence and structure of the pineal gland in Lacertilia and the evidence that it represents a third eye

in a rudimentary condition, it will be interesting to know that among some of the earlier mammals the pineal gland may have assumed functional importance as an eye. Prof. Henry F. Osborn [85] shows that in the skull of the curious mammal Tritylodon, of Owen, there is seen a parietal foramen in exactly the same position and relation as in the lizard Sphenodon.

Professor Osborn regards this fact of remarkable interest, as it adds greatly to the rapidly accumulating evidence for the reptilian affinities of the mammalia. Professor Owen, in the description of this unaccountable opening, suggested that it might be due to posthumous injury.

Professor Marsh,[86] in a description of the skull of Diplodocus, a Dinosaur, describes a fontanelle in the parietal on the median line directly over the cerebral cavity. He adds, however, that this may be merely an individual variation.

Professor Cope [87] observes an enormous fronto-parietal foramen in the skull of *Empedocles molaris*, a curious creature from the Permian.

It would appear evident from these facts that at one time the pineal gland, which in the mammals is in a rudimentary condition and in certain Lacertilia sufficiently perfect, as an eye, to be sensitive to light impressions at least, was, in certain extinct mammals and reptiles, of large size and functionally active. It is a significant fact that no sooner does some one opposed to evolution undertake to lay down the law by setting a boundary to type features, than a discovery is made that breaks down the barrier. Thus Dr. Thomas Dwight,[88] in an interesting memoir on the "Significance of Bone Structure" in which he makes a brave defence for teleology, says, in speaking of the persistence of the vertebrate plan, " There are never, for instance, more than two eyes or one mouth or two pairs of limbs," and, lo! an extra eye is immediately added.

Dr. Spencer Trotter [89] has made a study of the collar bone and its significance, in which he accounts for its presence or absence in mammalia by correlating it with the life habits of the animal in the use of the fore limb. He says " Every fully developed tissue in an organism is needed or it would not be there; and just so soon as by increasing change in life and habits it becomes a factor of less and less importance to the animal, it fails more and more to attain its former standard of development, and in time

falls back to the primitive condition from which it arose and finally disappears."

Many new and interesting facts have been added sustaining the affinity between the birds and reptiles. Prof. O. C. Marsh [90] made a careful study of the Archeopteryx in the British Museum. The new points he has added bring out still more strongly the extraordinary characters blended in this creature. Among other features he discovered the separate condition of the pelvic bones, and shows that while it must be considered a bird, yet it has true teeth, bi-concave vertebræ, three separate fingers in each hand, all furnished with claws, metatarsals and metacarpals, equally unanchylosed and the pelvic bones separate, as already mentioned.

Dr. J. Amory Jeffries,[91] in a study of the claws and spurs on birds' wings, has presented an interesting table showing the number of phalanges in each finger, from the highest to the lowest family of birds, with the presence or absence of claws recorded for each finger. This table shows very clearly that the higher birds have fewer phalanges and no claws, and as one approaches the lower families the phalanges increase in number, the first finger having two phalanges and the second and third fingers being tipped with claws.

In a brief study of the tarsus of low aquatic birds,[92] made with special reference to the interpretation of the ascending process of the astragalus with the intermedium of reptiles, I observed a separate centre of ossification for this so-called process, observed its unquestionable position between the tibiale and fibulare, its increase in size with the growth of the bird and its final anchylosis with the proximal tarsal bones. In the bones of a young Dinornis, which through the courtesy of Dr. Henry Woodward I was kindly permitted to examine in the British Museum, the ascending process was large and conspicuous and firmly anchylosed with the coössified tarsals to the distal end of the tibia. Professor Marsh,[93] in a study of the metatarsal bones of Ceratosaurus, a Dinosaur discovered by him, found that the metatarsals coössified in the same manner as those of the Penguin.

The question as to the existence of a sternum in Dinosaurian reptiles has long been in doubt. Professor Marsh [94] has, however, discovered in Brontosaurus, one of the largest known Dinosaurs, two flat bones which he regards as clearly belonging to the sternum. They correspond to the immature stage of similar parts in birds.

Dr. Alexander Agassiz,[95] in a study of the young stages of certain osseous fishes, shows that while the tail is a modified heterocercal one, it is for all that in complete accordance with embryonic growth and paleontological development; and, independently, Dr. John A. Ryder[96] finds that "the median fins of fishes normally present five well-marked conditions of structure which correspond inexactly to as many stages of development, which, in typical fishes, succeed each other in the order of time."

Mr. James K. Thatcher[96a] in a study of the "Median and Paired Fins, a contribution to the history of vertebrate limbs" shows "that the limbs with their girdles were derived from a series of similar simple parallel rays, and that they were a specialization of the continuous lateral folds or fins evidenced in embryos, which were with some probability homologous with the lateral folds or metapleura of the adult Amphioxus."

A great amount of work has been done in making clear the earlier stages in the development of animals and breaking down the hard and fast lines which were formerly supposed to exist between the larger divisions. Dr. C. S. Minot,[97] in a series of papers on Comparative Embryology, in referring to the work accomplished says "These researches have completely altered the whole science of comparative anatomy and animal morphology by entirely upsetting a large part of Cuvier's classification and the idea of types upon which it was based, substituting the demonstration of the fundamental identity of plan and structure throughout the animal kingdom from the sponges to man."

Prof. C. O. Whitman,[98] in describing a "rare form of the blastoderm of the chick, in which the primitive groove extended to the very margin of the blastoderm, terminating here in the marginal notch first observed by Pander," justly contends that "in the origin of the embryo from a germ-ring by the coalescence of the two halves along the axial lines of the future animal, and, secondly, in the metameric division which followed in the wake of the concrescence," we have evidence of the annelidan origin of the vertebrates since concrescence of the germ bands is a well established fact for both chætopods and leeches.

The tracing of apparently widely divergent structures to a common origin has engaged the attention of many of our investigators. Not only has a large amount of evidence been offered to show a common origin of widely separated structures, but memoirs of a

speculative and theoretical character have given us a possible clew to the avenues we may follow in further establishing a proof of the unity of origin of forms and parts.

Dr. Francis Dercum[99] gives an interesting review of the structure of the sensory organs and urges that the evidence goes to prove the common genesis of these organs.

Prof. A. Hyatt[100] has presented an interesting study of the larval history of the origin of tissue. He attempts to show a phyletic connection between the Protozoa and Metazoa, and also to show that the tissue cells of the latter are similar to asexual larvæ "and are related by their modes of development to the Protozoa just as larval forms among the Metazoa themselves are related to the ancestral adults of the different groups to which they belong." Dr. John A. Ryder[101] has studied the law of nuclear displacement and its significance in embryology. In a discussion of this subject he says "The mode of evolution of the yelk is of great interest, and doubtless occurred through the working of natural selection. It is evidently adaptive in character, and the necessity for its presence as an appendage of the egg grew out of the exigencies of the struggle for existence."

Mr. H. W. Conn,[102] in a paper entitled "Evolution of the Decapod Zoæ" gives a number of striking and suggestive facts explaining the reason of the multiform and diverse character of the larvæ of decapod crustaceans. He shows in what way natural selection has affected the young. What has seemed an almost insoluble mystery, as to why the early stages of closely allied crustaceans should be so often diverse in their varied armature of long spines, their powers of rapid flight, etc., are explained on the ground of natural selection. In another memoir by the same author,[103] on the significance of the "Larval skin of Decapods," a very complete discussion of the views of authors are given. At the outset he shows that the crustaceans are a particularly favorable group for the study of phylogeny and then suggests the character of the ancestral form of the Crustacea from the significance of the larval envelope. The author infers from his studies that " all Decapods are to be referred back to a form similar to the Protozoæ (Zoæ) in which the segments of the thorax and probably of the abdomen were present, and whose antennæ were locomotive organs."

Not the slightest justice can be done this admirable discussion in the brief reference here made, but the perusal of it will certainly

impress one with the profound change which has taken place in the method of treating a subject of this nature compared to the treatment it might have received in pre-Darwinian days. Indeed the features discussed in this paper would not have attracted a moment's attention from the older naturalists.

Since Darwin published his provisional theory of Pangenesis it has provoked speculative efforts on the part of some of our naturalists to devise other hypotheses which might answer some of the objections urged against Darwin's hypothesis. Space will permit only a mention of a few of these papers. Prof. W. K. Brooks[104] presented, in brief abstract at the Buffalo meeting eleven years ago, a provisional theory of Pangenesis. These views more elaborated are now published in book form under the title of "The Laws of Heredity." An illustrious reviewer says it is the most important contribution on the speculative side of Darwinism that has ever appeared in this country. He has also aptly termed studies of this nature molecular biology. Dr. Louis Elsberg at the same meeting also read a paper on the plastidule hypothesis.

Dr. John A. Ryder[105] has made an interesting contribution entitled "The Gemmule *versus* the Plastidule as the Ultimate Physical Unit of Living Matter." In this paper he discusses Darwin's provisional theory of Pangenesis and shows it to be untenable from Galton's experiments.

Haeckel's provisional hypothesis of the Perigenesis of the Plastidule is clearly stated, and he closes by saying that the logical consequences of the acceptance of Haeckel's theory and with it the theory of dynamical differentiation—because the latter is no longer an hypothesis—forever relegate teleological doctrines to the category of extinct ideas.

The widespread public interest in Darwinism arose from the fact that every theory and every fact advanced in proof of the derivative origin of species applied with equal force to the origin of man as one of the species. The public interest has been continually excited, by the consistent energy with which the church, Catholic and Protestant alike, has inveighed against the dangerous teachings of Darwin. Judging by centuries of experience, as attested by unimpeachable historical records, it is safe enough for an intelligent man, even if he knows nothing about the facts, to accept promptly as truth any generalization of science which the church declares to be false, and conversely to repudiate with equal

promptness, as false, any interpretation of the behavior of the universe which the church adjudges to be true. In proof of this sweeping statement one has only to read the imposing collection of facts brought together by Dr. White, the distinguished ex-president of Cornell University, which are embodied in his work entitled "The Warfare of Science," as well as two additional chapters on the same subject which have lately appeared in the Popular Science Monthly. One then realizes the lamentable but startling truth that, without a single exception, every theory or hypothesis, every discovery or generalization of science has been bitterly opposed by the church, and particularly by the Catholic church which resists, and, as Huxley says, " must, as a matter of life and death, resist the progress of science and modern civilization."

Only the briefest reference can here be made to a few of the numerous contributions on the subject of man's relationship to the animals below him. The rapidly accumulating proofs of the close relation existing between man and the Quadrumana make interesting every fact, however trivial, in regard to the structure and habits of the higher apes.

Dr. Arthur E. Brown [106] has made some interesting experiments with the monkeys at the zoölogical gardens in Philadelphia. He found that the monkeys showed great fear, as well as curiosity, when a snake was placed in their cage, though they were not affected by other animals, such as an alligator and turtle. On the other hand, mammals belonging to other orders showed no fear or curiosity at a snake. These experiments, repeated in various ways, lead him to only one logical conclusion "that the fear of the serpent became instinctive in some far distant progenitor of man, by reason of his long exposure to danger and death in a horrible form, from the bite, and that it has been handed down through the diverging lines of descent which find their expression to-day in Homo and Pithecus."

The same author,[107] in an exceedingly interesting description of the higher apes, says " Mr. A. R. Wallace once called attention to the similarity in color existing between the orang and chimpanzee and the human natives of their respective countries. It would, indeed, seem as if but half the truth had been told, and that the comparison might be carried also into the region of mind; the quick, vivacious chimpanzee partaking of the mercurial disposi-

tion of negro races, while the apathetic slow orang would pass for a disciple of the sullen fatalism of the Malay."

Doctor Brown[108] has also given a description of the grief manifested by a chimpanzee on the death of its mate. His grief was shown by tearing his hair or snatching at the short hair on his head. The yell of rage was followed by a cry the keeper had never heard before, a sound which might be represented by hah-ah-ah-ah-ah uttered somewhat under the breath, and with a plaintive sound like a moan.

Mr. W. F. Hornaday[109] read at the Saratoga meeting of this Association an exceedingly interesting paper on the "Habits of the Orang" as observed by him in its native forests. He says "Each individual of the Borneo orangs differs from his fellows and has as many facial peculiarities belonging to himself alone as can be found in the individuals of any unmixed race of human beings." After recounting the many traits of the orang, heretofore regarded as peculiar to man, he says, "let any one who is prejudiced against Darwinian views, go to the forests of Borneo. Let him there watch from day to day this strangely human form in all its various phases of existence. Let him see it climb, walk, build its nest, eat and drink and fight like human 'roughs.' Let him see the female suckle her young and carry it astride her hip precisely as do the Coolie women of Hindostan. Let him witness their human-like emotions of affection, satisfaction, pain and childish rage — let him see all this and then he may feel how much more potent has been the lesson than all he has read in pages of abstract ratiocination."

Prof. W. S. Barnard several years ago, in a study of the myology of man and apes, showed that the scansorius muscle which Trail studied in the higher apes and which he supposed had no homologue in man was really homologous with the *Gluteus minimus* in man. Dr. Henry C. Chapman,[110] in a study of the structure of the orang outang, has confirmed the truth of Barnard's discovery. Doctor Chapman is led to infer that the ancestral form of man was intermediate in character, as compared with living anthropoids or lower monkeys, agreeing with them in some respects and differing from them in others.

The osteological affinities which man has with the Lemuroidæ, as insisted upon by Mivart, are also recognized by Cope.[111] In a general paper on the "Origin of Man and Other Vertebrates"

he says "An especial point of interest in the phylogeny of man has been brought to light in our North American beds. There are some things in the structure of man and his nearest relatives, the chimpanzee, orang, etc., that lead us to suspect that they had rather come from some extinct type of lemurs."

It would seem as if we must look farther back than the higher apes for the converging lines of man's relations with them. The earliest remains of man or the apes found fossil, presenting as they do marked types with little tendency to approach each other, would in themselves suggest an earlier origin for both stocks.

In a paper by Professor Cope [112] on "Lemurine Reversion in Human Dentition" he says, in concluding his article: "It may be stated that the tritubercular superior molars of man constitute a reversion to the dentition of the Lemuridæ of the Eocene Period of the family Anaptomorphidæ, and second, that this reversion is principally seen among Esquimaux and the Slavic, French and American branches of the European race."

In another paper by the same author [113] on the "Developmental Significance of Human Physiognomy," he compares the proportions of the body and the facial peculiarities of man with the higher apes and human infants and shows that the Indo-European, on the whole, stands higher than the other races in the acceleration of those parts by which the body is maintained in an erect position, and in the want of prominence of the jaws and cheek bones, which are associated with a greater predominance of the cerebral part of the skull and consequently greater intellectual power.

Dr. Harrison Allen,[114] in a study of the shape of the hind limb as modified by the weight of the trunk, dwells on the manner of articulation in the gorilla of the fibula with both calcaneum and the astragalus, as well as the fact that the astragalus in that genus possessed a broad deflected fibula facet and says "This peculiar projection is rudimental in the astragalus of civilized man, but was found highly developed in an astragalus from an Indian grave found at Cooper's point, New Jersey."

In my Buffalo address, I alluded to a paper by Prof. N. S. Shaler on the intense selective action which must have taken place in the shape and character of the pelvis in man on his assumption of the erect posture—the caudal vertebræ turning inward, the lower portion of the pelvis drawing together to hold the viscera, which had before rested on the elastic abdominal walls, the attending difficulty of

parturition, etc. Dr. S. V. Clevenger [115] has since called attention to other inconveniences resulting from man's escape from his quadrumanous ancestors. In a paper entitled "Disadvantages of the Upright Position," he dwells particularly on the valves in the veins to assist the return of blood to the heart which considered from the usual teleological point of view seems right enough; but why, he asks, should man have valves in the intercostal veins? He shows that in a recumbent position these valves are an actual detriment to the flow of blood: "An apparent anomaly exists in the absence of valves from parts where they are most needed, such as the venæ cavæ, spinal, iliac, hæmorrhoidal and portal. The azygos veins have imperfect valves. Place man upon 'all fours' and the law governing the presence and absence of valves is at once apparent, applicable, so far as I have been able to ascertain, to all quadrupedal and quadrumanous animals. Dorsad veins are valved; cephalad, ventrad and caudad veins have no valves." By means of two simple diagrams he shows clearly the distribution of valved and unvalved veins as they exist in mammals, and why in man the same arrangement becomes detrimental. He dwells on the number of lives that are sacrificed every year by the absence of valves in the hæmorrhoidal veins. He also mentions other disadvantages in the upright attitude, as seen in the position of the femoral artery, even with man's ability to protect it. Its exposed condition is a dangerous element. Inguinal hernia of rare occurrence in mammals occurs very often in man; at least twenty per cent being affected. Strangulated hernia also causes many deaths. Prolapsus uteri and other troubles and diseases are referred to by Doctor Clevenger as due to the upright position. In other words the penalties of original sin are in fact the penalties resulting from man's assumption of the erect posture.

In another paper by the same author,[116] on the "Origin and Descent of the Human Brain," he gives an interesting sketch of the phylogenesis of the spinal cord to its ultimate culmination in the development of the brain of man. He says that the most general interest centres in the large mass of cells and nerve fibres called the cerebrum. "In the Ornithorhynchus, it is smooth and simple in form, but the beaver also has an unconvoluted brain which shows at once the folly of attaching psychological importance to the number and intricacy of folds in animal brains. With phrenology, which finds bibativeness in the mastoid process of the

temporal bone and amativeness in the occipital ridge, the convolutional controversies must die out, as has the so-called science of palmistry, which reads one's fate and fortune in the skin-folds of the hand."

Prof. Alexander Graham Bell [117] has presented a memoir to the National Academy on the "Formation of a Deaf Variety of the Human Race" in which he shows by tables a series of generations of certain families in which the progenitors being deaf mutes this peculiarity becomes perpetuated in many of the descendants. Recognizing fully the laws of heredity, natural selection, etc., he shows that the establishment of deaf-mute schools, in which a visual language is taught which the pupils alone understand tends to bring them into close association with each other; and, that naturally with this seclusion, acquaintance ripens into friendship and love and that statistics show that there is now in process of being built up a deaf variety of man.

Dr. W. K. Brooks,[118] animated by the cogency of Professor Bell's reasoning, is led to prepare an article entitled "Can Man be Modified by Selection?" In this paper he discusses the startling proposition of Professor Bell and recognizes the convincing proof which he furnishes to show that the law of selection does place within our reach a powerful influence for the improvement of our race. The striking character of the tables of facts presented by Professor Bell and the significant suggestions of Doctor Brooks lead one to consider how far the influence of selection has had to do with the character of great communities, as to their intelligence or ignorance. When we see nations of the same great race stock, one showing a high percentage of illiterates, a high death rate, degradation and ignorance, while just across the borders another nation, apparently no better off so far as physical environments are concerned, with percentage of illiterates and death rate low, intelligent and cleanly, we are led to inquire if here a strict scientific scrutiny with careful historical investigation will not reveal the cause of these conditions. Can it be proved beyond question that the illiteracy and degradation of Italy and Spain up to within recent years, at least, are the result of centuries of church oppression and the Inquisition, destroying at once, or driving out of the land all independent thinkers and at the same time forcing her priests to lead celibate lives and inducing others of cultivated and gentle minds to lead cloister lives? Is it also a fact, as Alphonse

de Candolle asserts, that by far the greater number of distinguished scientists have come from Protestant pastors? He gives a significant list of eminent men whose fathers were Protestant pastors saying that had they been priests of another religion leading celibate lives these men would not have been born.

It is considered an intrusion into matters which do not concern science when such inquiries are made, but the scientist has very deeply at heart the intellectual and moral welfare of the community. If the cause of degradation and ignorance, of poverty, of contagious disease, or of any of the miseries which make a nation wretched can be pointed out by scientific methods, then it is the stern duty of science to step in and at least show the reasons, even if the remedy is not at once forthcoming. The men who would be reformers and agitators and who by their earnestness and devotion get the attention of multitudes are unfit for their work if they show their ignorance, as most of them do, of the doctrines of natural selection and derivation.

Dr. C. S. Minot [119] read a paper before the Cincinnati meeting of this Association suggesting a rather startling proposition as to whether man is the highest animal, which led Dr. W. N. Lockington [120] to reply in a very able article entitled "Man's Place in Nature."

The great problem of food supply has led to legislative enactments for the purposes of regulating the trapping and netting of game and fish. State and government grants have been made for fish commissions; but unless the public are clearly educated in the rudiments of zoölogical science and the principles of natural selection, appropriations will come tardily and in limited amounts. Dr. W. K. Brooks, [121] in his report to the State of Maryland as one of the oyster commissioners, after showing the absurd way in which the problem of oyster protection has been dealt with and strenuously urging the necessity of oyster culture, calls attention to the fact that "civilized races have long recognized the fact that the true remedy is not to limit the demand, but rather to increase the supply of food, by rearing domestic sheep and cattle and poultry in place of wild deer and buffaloes and turkeys, and by cultivating the ground instead of searching for the natural fruits and seeds of the forests and swamps."

Mr. Ernest Ingersoll,[122] author of the "Report on the Oyster Industry," 10th U. S. Census, has, in an address before the Geo-

graphical Society of New York, a striking sketch of the effect of the white man on the wild animals of North America, showing that had the Indians remained in possession, little, if any, change would have taken place. The Indian, like the predaceous animals, hunts only for food and shows even in this habit, a wholesome self-restraint, never killing wantonly. He called attention to the survival of a number of small birds about the dwellings of man as the result of favorable conditions, such as a constant supply of food, etc. He shows that the contact of man in the main has been disastrous. His remarks on the oyster are timely; he shows its extermination along the coast by man's agency. "Hardly more than a century has elapsed since men believed that the oyster beds of New York were inexhaustible and that a small measure of legal protection, feebly maintained, was quite enough to sustain them against any chance of decay. So they thought in Massachusetts, where the oysters have not only disappeared but have been forgotten. So they think now in Maryland and Virginia, where their fond expectations are destined to equal downfall."

Prof. William H. Brewer,[123] in a paper on the "Evolution of the American Trotting-Horse," shows that the trotter is an American product and that it is still in process of evolution. He gives a column of figures to show the speed that has been attained in this new form of motion, from a speed of three minutes in 1818 down to two, ten and a quarter minutes in 1881. The materials for a curve is offered to mathematicians, and Prof. Francis E. Nipher,[124] in a mathematical article on the subject, shows that a definite time of ninety-one seconds will ultimately be attained by the American trotter. Mr. W. H. Pickering,[125] however, urges some objections to the deductions of Professor Nipher.

In drawing to a close this very imperfect summary of what American zoölogists have accomplished for evolution many other distinguished contributors might have been mentioned. The work of eminent physiologists and paleontologists has hardly been considered, nor has the long array of botanical facts for Darwin as revealed in the fascinating study of the relations which exist between flowering plants and insects, contrivances for cross fertilization, means of plant dispersion, etc., and the distinguished botanists connected with this work, received attention here. Indeed the proper limits for an address of this nature have been far exceeded.

Suffice it to say that all these students have worked from the standpoint of Derivative doctrines. A still greater triumph to Darwinism are the evidences of gradual conversion still going on among a few isolated workers who still remain stubborn, yet yielding to the pressure of these views by admitting features that ten years ago they repudiated.

There are two points to be emphasized here in closing, and one is that American biological science stands as a unit for evolution, and the other is, the establishment of a great generalization which shows that when intelligence became a factor in animals, it was seized upon to the relative exclusion of other characteristics. This generalization offers an unassailable argument to-day for a wider, broader and deeper education for the masses. The untold misery and suffering of the working classes as witnessed in their struggles of the last two years would have been avoided had the rudiments of social science—even a knowledge of the value and significance of simple statistics, been appreciated by them.

The startling paper of Dr. Seaman [126] on the "Social Waste of a great City" shows the blundering, criminal way in which municipalities are controlled by coteries ignorant alike of Science and the beneficent mission she stands waiting to enter upon.

[Within ten years a number of general works on Evolution have appeared, the most important of which have been the "Law of Heredity" by Dr. W. K. Brooks, to which allusion has already been made, and the "Origin of the Fittest" by Prof. E. D. Cope, in which are brought together the various papers, memoirs, addresses, etc., of the author which have appeared from time to time in scientific journals and magazines. Nearly all the addresses read, within the past ten years, before this association by the presiding officers who were zoölogists have been imbued with Darwinism and Derivation. The titles of the general articles which have appeared on evolution would fill a large catalogue.

The general addresses on the subject are legion. Indeed, as the revered botanist Asa Gray has well remarked, "Dante literature and Shakespeare literature have been the growth of centuries but Darwinism filled teeming catalogues during the life-time of the author."

While no reference can be made to these various publications, allusions must be made to the Darwin Memorial meeting of the Biological Society of Washington as containing a most appreciative résumé of the labors of the great naturalist. A perusal of the addresses on that occasion brings to mind very vividly the comprehensive scope of the work of this great man. The Introductory by Prof. Theodore Gill is a strong sketch of the

wonderful revolution wrought in the methods and convictions of naturalists by the doctrines of Darwin. Of great interest and value also are the succeeding addresses read at that meeting, which were a "Biographical Sketch" by Dr. William H. Dall, "The Philosophic Bearings of Darwinism" by Major John W. Powell, "Darwin's Coral Island Studies" by Mr. Richard Rathbun, "Darwin's Investigations on the Relation of Plants and Insects" by Prof. Charles V. Riley, "Darwin as a Botanist" by Mr. Lester F. Ward, "Darwin on Emotional Expression" by Mr. Frank Baker, closing with "A Darwinian Bibliography" by Mr. Frederick W. True.

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REPORTS OF COMMITTEES.

Report of the Committee on Indexing Chemical Literature.

The Committee on Indexing Chemical Literature respectfully presents to the Chemical Section its fifth annual report.

During the year Professor Charles E. Munroe completed and printed his Index to the Literature of Explosives, Part I, in an octavo pamphlet of forty-two pages. Part I embraces the bibliography of the subject as found in the following complete sets of periodicals:

Journal Royal United Service Institution, 1857–1885, 28 vols.

American Journal of Science, 1819–1886, 130 vols.

Philosophical Transactions (Royal Society), 1665–1882, 173 vols.

Revue d' artillerie, 1873–1884, 25 vols.

Proceedings U. S. Naval Institute, 1874–1885, 11 vols.

H. M. Inspector of Explosives (Reports), 1871–1885, 75 numbers, making in all no less than 442 volumes, which have been examined and indexed. In Part II, the author intends to continue with additional periodicals, and finally to give a subject and an author-index to the whole.

Dr. H. Carrington Bolton has published two brief bibliographical helps for chemists; the titles of which will be found in the list of Indexes at the close of this report.

Mr. A. Tuckerman of New York has completed an Index to the Literature of the Spectroscope, which will be printed by the Smithsonian Institution.

Though of local interest only, we mention in this connection a useful check-list of scientific journals published by a member of the Association. Mr. Clement W. Andrews has compiled a "List of the Scientific Periodicals in the Libraries of the various departments of the Massachusetts Institute of Technology [Boston], April, 1887." This list contains two hundred and forty-seven titles arranged alphabetically by the first word, with the exception of Official Reports. In connection with each title, indications are

given of the particular departments of the Institute, nine in number, in which the periodical may be found.

Reports of progress have been received from the following gentlemen, on the indexes named:

Professor F. W. Clarke, Specific Gravity Tables.

Professor W. H. Seaman, American Chemical Patents.

Mr. George F. Kunz, Gems and Precious Stones.

Mr. Clement W. Andrews, Milk Analysis.

Dr. F. E. Engelhardt, Common Salt.

Dr. L. P. Kinnicutt, Meteorites.

Prof. Erastus G. Smith, Aluminium.

Mr. William Beer, Bibliography of Scientific Bibliographies.

The late lamented Professor Wm. Ripley Nichols left his Index to the Literature of Carbon Monoxide unpublished, yet so well advanced as to permit its extension and completion; this has been undertaken by Mr. Augustus H. Gill of the Massachusetts Institute of Technology.

Offers of voluntary coöperation have been received from two chemists: Dr. Frank W. Traphagen, of Staunton, Va., has undertaken to compile an Index to the Literature of Bromine, and Mr. A. P. Bjerregaard of the Astor Library, New York, has begun work on an Index to the Literature of Chromium, both subjects having been suggested by the Committee.

As stated in an earlier report the Committee deems it advisable to note important bibliographical undertakings which come under its observation. Attention is called to the extensive Index to Meteorological Literature now preparing by Mr. C. J. Sawyer of the Signal Office, War Department. It is a classified index containing about 50,000 titles on meteorology and terrestrial magnetism including separate works, memoirs and published observations. It will be accompanied by a full author-index. The date of publication of the manuscript will depend on congressional action.

When committees for the preparation of indexes and bibliographies of special topics are appointed by both the American and the British Associations for the Advancement of Science, it is eminently desirable that they should coöperate as far as practicable. A beginning has already been made in the direction of an International Committee by the appointment of one of the members of our Committee (Prof. Leeds) to serve on the Committee of the British Association for indexing the literature of Solution. The circulars

issued for the members contain a scheme of classification and a list of the periodicals, thirty-one in number, which it is proposed to index. The project also calls for original work. Those desiring further information should address W. W. S. Nicol, the Secretary, at the Mason Science College, Birmingham.

Members of the Chemical Section who attended the Buffalo meeting will remember that one of the Committee discussed in a brief article the desirability of greater uniformity in the abbreviations of Journal titles and suggested the formation of a Standard List for chemistry.

The proposition was favorably received by the Section and the Committee, reinforced by Prof. C. K. Wead and Mr. S. H. Scudder, has devoted much thought and time to the preparation of such a list. During the progress of the work the Committee was favored with suggestions from Mr. Clement W. Andrews of the Massachusetts Institute of Technology and from Prof. William Frear of Pennsylvania State College. Both of these gentlemen kindly drew up lists of abbreviations for the use of the Committee. The Committee does not think it necessary in this place to detail the many difficulties encountered, but present to the Section a succinct statement of the principles, by which it was governed in preparing the Standard List.

PRINCIPLES FOR ABBREVIATION OF TITLES.

1. Follow established usages when possible.
2. While seeking brevity avoid obscurity.
3. Brevity and perspicuity are not to be sacrificed to consistency.
4. Follow the rules 1, 3, and 4 as laid down by Dr. J. S. Billings, viz.:—"(1) Follow the exact order of words of the title. (3) Follow the orthographical usages of each language; this rule disposes of capitalization. (4) Attain uniformity as far as possible."
5. If possible, indicate languages of titles by use of articles and conjunctions, or by spelling.
6. When necessary to differentiate add names of editors or places of publication.
7. Abbreviations should be intelligible without a key.
8. Optional words are placed in parentheses.

9. Obscure journals require fuller abbreviations than those frequently cited.

These principles were adopted after personal conference and correspondence, by a majority of the Committee; Dr. Alexis A. Julien, however, though welcoming this provisional list, expressed the wish for briefer abbreviations, and at his request we insert a summary of his views.

Dr. Julien thinks further contraction of the abbreviations desirable, chiefly by omission of vowels, even if established usages are sometimes abandoned. He thinks that consonants indicating roots philologically are in many cases sufficient; such as *Grn.* for *Giorn.*, etc.; he favors the following *Ch.* for *Chem.* and for *Chim.* since the articles or conjunctions indicate the languages. Where the title of a journal is not readily confounded with that of any other he favors utmost contraction. He thinks the Standard List of Abbreviations will be more useful and more widely adopted if the abbreviations are shortened to a greater degree than in the subjoined list.

Mr. S. H. Scudder also dissents from the views of the majority of the Committee, approaching those of Dr. Julien but not going so far. He favors omission of all articles, prepositions and conjunctions, and regards the Provisional List of Abbreviations as burdensome and as supposing an unreasonable lack of acquaintance with names of Journals. He also somewhat prefers adding place of publication instead of name of editor when necessary to differentiate, and would always end abbreviations (unless elliptical) with a consonant. He suggested several shorter contractions than those of the manuscript submitted to him, which the Chairman has ventured to incorporate in the Provisional List.

The majority of the Committee took a strongly conservative view of the matter. They felt that the abbreviations should in every case suggest to one moderately familiar with chemical periodical literature the name of the journal indicated; they therefore avoided the use of symbols, or single letter abbreviations except in the sole instance of "J" for journal — already conventional. At the same time the abbreviations in the following list will be found briefer and more easily recognized than those in the Catalogue of Scientific Papers published by the Royal Society, or in the Index-Catalogue of the Library of the Surgeon General's Office. Yet they

believe they are full enough to be used without obscurity, in such Catalogues as these, covering almost the whole range of scientific journals.

The members of the Committee do not regard this report as the proper place to explain fully the reasons which have led to the adoption of each of the two hundred abbreviations submitted herewith; nor do they feel called upon to defend their choice. But they do earnestly desire that, before their critics undertake further condensation in certain cases that seem to be needlessly extended, they shall examine the titles of a compendious bibliography of scientific periodicals. By so doing they will perceive the necessity of differentiation, and that provision has been made to avoid confounding journals having closely similar titles.

The Committee also realizes that it may often be desirable to shorten a given abbreviation for special reasons, as for example in printing tables, or where a large number of citations are made from a single journal. This conversion of abbreviations into "symbols" must be left to the judgment and necessities of individuals.

In presenting to the Section the draft of a list of abbreviations for their scrutiny and approval or disapproval, the Committee desires it to be distinctly understood that the list is a provisional one and subject to such amendments as the Section may direct. The Committee respectfully suggests that the Provisional List annexed to this Report be printed for use of members of the Chemical Section and that the Section take no action upon the list as a whole until the meeting of 1888. In the interim the Provisional List can be subjected to the test of usage, and improvements or amendments which suggest themselves on trial can be recorded. All suggestions will be welcomed by the Chairman of the Committee, to whom they should be addressed.

Several years having elapsed since the publication of a list of the indexes in print, the Committee deems it advisable to republish the list brought up to date, together with memoranda indicating where the indexes can be obtained. Unfortunately some are out of print.

The Committee again thanks the Association and the Smithsonian Institution for services which save the Committee from incurring the expenses of printing and mailing reports.

The Committee begs leave to refer chemists receiving this report to their oft-announced appeals for voluntary coöperation in the

work which it has in charge. Sample copies of Indexes and other information can be had by addressing the chairman, care of the Smithsonian Institution.

H. CARRINGTON BOLTON, *Chairman.*
F. W. CLARKE, (absent in Europe),
ALBERT R. LEEDS,
ALEXIS A. JULIEN,
JOHN W. LANGLEY,
SAMUEL H. SCUDDER,
C. K. WEAD.

Appendix to Report of Committee on Indexing Chemical Literature.

[A.] List of Indexes to Chemical Literature.

(1) *Uranium*, Index to the Literature of. By H. Carrington Bolton. Annals of the New York Lyceum of Natural History, Vol. IX, February, 1870. 15 pp. 8vo.

(2) *Outlines of a Bibliography of the History of Chemistry.* By H. Carrington Bolton. Annals Lyceum Nat. Hist., Vol. X, pp. 352–361. New York, 1873.

(3) *Manganese*, Index to the Literature of; 1596–1874. By H. Carrington Bolton. Annals of the Lyceum of Natural History, New York, Vol. XI, November, 1875. 44 pp. 8vo.

(4) *Titanium*, Index to the Literature of; 1783–1876. By Edw. J. Hallock. Annals of the N. Y. Academy of Sciences, Vol. I, Nos. 2 and 3, 1877. 22 pp. 8vo.

(5) *Vanadium*, Index to the Literature of. By G. Jewett Rockwell. Annals of the N. Y. Academy of Sciences, Vol. I, No. 5, 1877. 13 pp. 8vo.

(6) *Ozone*, Index to the Literature of; 1875–1879. By Albert R. Leeds. Annals of the N. Y. Academy of Sciences, Vol. I, No. 12, 1880. 32 pp. 8vo.

(7) *Peroxide of Hydrogen*, The Literature of; 1818–1878. By Albert R. Leeds. Annals of the N. Y. Academy of Sciences, Vol. I, No. 13, 1880. 11 pp. 8vo.

(8) *Electrolysis*, Index to the Literature of; 1784–1880. By W. Walter Webb. Annals of N. Y. Academy of Sciences, Vol. II, No. 10, 1882. 40 pp. 8vo.

(9) *Speed of Chemical Reactions*, Literature of. By Robert B. Warder. Proceedings of the Am. Assoc. Adv. Science, Vol. XXXII, 1883. 3 pp. 8vo.

(10) *Starch-sugar*, Bibliography of. By Edw. J. Hallock. Appendix E to Report on Glucose prepared by the National Academy of Sciences in response to a request made by the Commissioner of Internal Revenue. U. S. Internal Revenue, Washington, D. C., 1884. 44 pp. 8vo.

(11) *Ozone*, Index to the Literature of, 1879–1883; accompanied by an Historical-Critical Résumé of the Progress of Discovery since 1879. By Albert R. Leeds. Annals N. Y. Academy of Sciences, Vol. III, p. 137, 1884. 16 pp. 8vo.

(12) *Peroxide of Hydrogen*, Index to the Literature of; 1879–1883. By Albert R. Leeds. Annals N. Y. Academy of Sciences, Vol. III, p. 153, 1884. 3 pp. 8vo.

(13) *Dictionary of the Action of Heat upon Certain Metallic Salts*, including an Index to the principal Literature upon the Subject. Compiled and arranged by J. W. Baird, contributed by A. B. Prescott. New York, 1884. 70 pp. 8vo.

(14) *Bibliography of Petroleum*, by Prof. S. F. Peckham. Report on the Production, Technology and Uses of Petroleum and its Products. Report of the tenth census of the United States, Vol. X, 1884, 4to; pp. 281–301. [A comprehensive bibliography of *Bitumen* and its related subjects.]

(15) *A Catalogue of Chemical Periodicals*, by H. Carrington Bolton, Annals N. Y. Academy of Sciences, Vol. III, pp. 159–216. New York, 1885. 8vo. Also chemical News Print, London, 1886,

(16) *Iridium*, Bibliography of the Metal, by Nelson W. Perry, in Prof. W. L. Dudley's paper on Iridium published in Mineral Resources of the United States, calendar years 1883 and 1884. Washington, 1885. 8vo.

(17) *Uranium*, an Index to the Literature of; 1789–1885. By H. Carrington Bolton. Smithsonian Report for 1885. Washington, 1885. 36 pp. 8vo.

(18) *Explosives*, Index to the Literature of. Part I. By Charles E. Munroe, Baltimore, 1886. 42 pp. 8 vo.

(19) *Supplement to a Catalogue of Chemical Periodicals*. By H. Carrington Bolton. Annals N. Y. Academy of Sciences, Vol. IV, 1887. 4 pp. 8vo.

(20) *Short Titles of Chemical Periodicals current in* 1887. By H. Carrington Bolton. J. of Analytical Chemistry, Vol. I, Part I, 1887. 4 pp. 8vo.

NOTE. Copies of 1, 3, 9, 13, 15, 16, 17, 18 and 19 can be obtained by addressing the respective authors. Copies of 2, 4, 5, 6, 7, 8, 11, 12, can be had of Prof. D. S. Martin, New York Academy of Sciences. Copies of 10 can be had of the Commissioner of Internal Revenue. Copies of 14 can be had of the Census Bureau, Washington, D. C.

[B]. PROVISIONAL LIST OF ABBREVIATIONS OF TITLES OF CHEMICAL JOURNALS.

The numbers refer to the Catalogue of Chemical Periodicals by H. Carrington Bolton, New York, 1885, 8vo. Titles 183–196 in the Supplement, New York, 1887 [Nos. 15 and 19 of the preceding list].

1. Afh. Fys. Kemi.
2. Agenda chim.
3. Chem. Ztg.
4. Allg. chem. Bibl. (Trommsd.).
5. Allg. J. Chem. Scherer.
   a N. allg. J. Chem. Gehlen.
   b J. für Chem. Gehlen.
   c J. für Chem. Schweigger.
   d J. prakt. Chem.
6. Alm. di chim. agric.
7. Alm. de chim.
8. Alm. Scheid. Apoth.
   a Taschenb. f. Scheid.
9. Am. Chem. J.
10. Am. Chemist.
11. Am. Lab.
12. Analyst.
13. Ann. Chem. (Liebig).

14. Ann. chim. phys.
15. Ann. di chim. (Brugnatelli)
16. Ann. fis. chim.
17. Ann. Chem. Med.
18. Ann. Chem. Phil.
19. [Refer to 14].
20. Ann. Chym. Pract. Pharm.
21. Ann. Pharm. Bastick.
22. Ann. Phil. (Thomson).
23. Annuaire prod. chim.
24. Annuaire chim.
25. Annuaire sci. chim.
26. Annual Rep. Chem.
27. Anno. alm. pei chim.
28. Anno. chim. ital.
29. Anno. scienze chim. nat.
30. Anno. scienze chim. farm.
31. Anti-Adult. Rev.
32. Arch. der Agr.-Chem.
33. Arch. for Pharm. Trier.
34. Arch. ges. Naturl.
35. Arch. für theor. Chem.
36. Arch. thier. Chem.
37. Arsb. Phys. Chemi.
38. Ausw. Abh. Chem. Crell.
39. Ausw. Ann. Chem. Crell.
40. Beitr. Chem. Wasserberg.
41. Beitr. Min. Klaproth.
42. Beitr. Chem. Bucholz.
43. Arch. für physiol. Chem.
44. Ber. d. chem. Ges. (*or* Ber.)
45. Berl. Jahrb. Pharm.
46. Bibl. phys. Lit. (Hermbstädt.)
    Ann. Chem. Lit.
47. Boston J. Chem.
48. J. de pharm.
49. Bull. math. chim. (Férussac.)
50. Casopis chem.
51. Centrbl. Agr.-Chem.
52. Chem. Gaz.
    Chem. News.
53. Chem. News. Am. Repr.
54. Chem. Record. (Lond.)
55. Chem. Rev. (Lond.)
56. Am. Chem. Rev.
57. Chem. Kal.
57*a*. Techn.-chem. Jahrb.
58. Chem. Ackersmann.
59. Chem. Ann. Crell.
60. Chem. Ind. (Jacobsen.)
61. Chem. phys. oefen.
62. Chem. Archiv Crell.
63. Chem. J. Crell.
64. Chem.-pharm. archief.
65. Chem. techn. Mitthl.
66. Chem. techn. Repert.
67. Chemist. Mongredieu.
68. Chemist. Watt.
69. Chem. and Drug.
70. Chem. Advocate.
71. Chem. and Meteor. J. (Amherst.)
72. Chem. Desk Comp.
73. Chemists' J.
74. Chimiste, Bruxelles.
75. Chimiste, Paris.
76. Compt. rend. *or* C.R.
77. C. R. chim. Montpellier.
78. Crell's Chem. J. Lond.
79. Deutscher Chem. Kal.
80. Edinb. J. Sci.
81. Fortschr. techn. Chem.
82. Fortschr. theor. Chem.
83. Fortschr. Chem. Köln.
84. Gazz. chim. ital.
85. Gazz. chim. techn. (Sembenini).
86. Gazz. farm. (Sembenini).
87. Gazz. farm. chim. (Venezia).
88. Giorn. fis-chim. ital.
89. Giorn. chim. veterin.
90. Giorn. farm. chim. (Gajani).
91. Giorn. di farm. Chiappero.
92. Giorn. di farm. Cattaneo.
    a Bibl. di farm.
    b Ann. di farm. appl. (Polli).
93. Giorn. di fis. Majocchi.
94. Giorn. di fis. Brugnatelli.
95. Obs. sur. phys.
    a J. de phys.
96. Jahrb. Erfind.
97. Jahrb. ökon. Chem.

98. Jsb. Agr.-chem. (Ditmer).
99. Jsb. rein. Chem.
100. Jsb. Agr. Chem.
101. Jsb. chem. Techn. (*or* Wagner's Jsb.)
102. Jsb. phys. Wiss. (*or* Berzelius' Jsb.)
103. Jsb. Chem.
104. Jsb. thier Chem.
105. J. chim. phys. Van Mons.
106. J. chim. med.
107. J. chim. Van Mons.
108. J. der Pharm. Trommsd.
109. J. der Phys. Gren.
a N. J. der Phys. Gren.
b Ann. der Phys. Gren.
c Ann. der Phys. Gilbert.
d Ann. der Phys. Pogg.
e Ann. der Phys. Wied.
f Beibl. Ann. der Phys.
110. J. Phys. Krönig.
111. J. techn. Chem.
112. J. Appl. Chem.
113. Nicholson's J.
114. J. Soc. Chem. Ind.
115. K. phys. chem. Abh.
116. Ztschr. Chem.
117. Laboratorium.
118. Laboratory, Boston.
119. Laboratory, Lond.
120. Listy chem.
121. Mag. f. Apoth. (Elwert.)
a Report. f. Chem. (Elwert.)
122. Mag. höhere Naturw.
123. Mech. and Chem.
124. Mél. phys. chim.
125. Mem. prat. chim.
126. Mem. Columb. Chem. Soc.
127. Misc. chim. fis. (Pisa.)
128. Mitthl. Chem. (Kletzinsky).
129. Mitthl. Lab. Chem. Brünn.
130. Monatsh. Chem.
131. Monit. prod. chim.
132. Month. Mag. Pharm.
133. Naturh. chem. Notiz.
134. Mag. für. Pharm. (Geiger.)
135. Orosi.
136. Penny Mech.
137. Pharm. Times.
a Chem. Times.
138. Pharm. Centrbl.
b Chem. Centrbl.
139. Pharmacist.
140. Phil. Mag.
141. Piria.
142. Proc. Am. Chem. Soc.
a J. Am. Chem. Soc.
143. Proc. Chem. Soc.
a Q. J. Chem. Soc.
b J. Chem. Soc.
144. Raccolta fis. chim.
a Ann. fis. Zantedeschi.
145. [Refer to 37.]
146. Recherches phys.-chim.
147. Recueil trav. chim.
148. Rép. chim. Paris.
149. Rep. chim. pure.
Rép. chim. appl.
Bull. Soc. chim. (Paris.)
150. Rép. de pharm. Bruxelles.
151. Rep. de pharm. Paris.
152. Rep. anal. Chem.
153. Rep. chem. Pharm. St. P.
154. Rep. d. Pharm. (Buchner.)
155. Rep. org. Chem. (Löwig.)
156. Rep. Pharm. Russland.
156*A*. Rev. hebd. chim.
157. Rev. Sc. Quesneville.
a Monit. Sc. Quesneville.
158. Rev. ind. chim.
159. Revista chim.
160. Samml. Abh. Chem. Hochheimer.
161. Scheik. bibl.
162. Scheik. bijdr.
163. Scheik. onderzoek.
164. School Mines. Q.
165. Taschenb. Scheik.
166. Techn.-chem. Kal.
167. Techn.-chem. Gewerbebl.
168. Techn.-chem. Jahrb.
169. Tekno-kem. J.

170. Tidssk. anv. Chemi.
171. Tidssk. Phys. Chemi.
172. Tijdsch wet. pharm.
173. Toeg. scheik.
a Maandbl. toeg. scheik.
174. N. Gegenst. Chem. (Richter.)
175. Unters. Liebig's Lab.
176. Vjschr. techn. Chem.
177. Yearbook Pharm.
178. Ztschr. anal. Chem.
179. Ztschr. chem. Grossgew.
180. Ztschr. physiol. Chem.
181. Zhurnal Khim.
182. Zpravy Chem.
183. Bull. assoc. chim. France.
184. Bull. Chem. Soc. Washington.
185. Chemiker. u. Drogist.
186. Chem.-techn. Centrlanz.
187. Deutsche Chem.-Ztg.
188. J. Anal. Chem.
189. Meddel. Carlsberg Lab.
190. N. Y. Analyst.
a Am. Analyst.
191. Skand. Kem. Centrlblad.
192. Suppl. enciclop. chim.
193. Tokyo K. Kaishi.
194. Vjschr. Chem. Nahr.
195. Ztschr. Chem. Ind.
196. Ztschr. phys. Chem.
Am. J. Sci.
Arch. sc. phys.
Jen. Ztschr.
Sitzb. Akad. Berlin.
Sitzb. Akad. Wien.
Phil. Trans. Lond.
Proc. Roy. Soc.
Proc. Am. Acad.
Ann. N. Y. Acad. Sci.
Proc. Acad. Nat. Sci. Phil.

The number of Society Transactions publishing chemical papers is very great, and the list (added at the suggestion of some members of the committee) could be greatly extended.

Report of the Committee on Anatomical Nomenclature, with Special Reference to the Brain.

The Committee has had under consideration a number of changes or modifications of terms now in general use. These have been proposed either with a view to the correlation and simplification of the already existing nomenclature, or for the more accurate limitation of certain terms. An attempt was made to formulate some general rules, especially for those terms which describe the relations of organs and their aspects with regard to the vertebrate axis.

It was found, however, that, in order to do this successfully, and produce a result worthy of the Association, it would be necessary to include in the scheme of revision not only English terms, but also those of the principal European languages: especially French, German and Italian, as well as the parent Latin. It is often found that excellent terms for a structure exist in one of these languages while objectionable ones are found in the others. Any changes to be recommended should, it is believed, be such as could readily be adopted in all.

That this is a work of considerable magnitude will easily be seen. Any partial scheme might, however, be found to clash with the one which the Committee hope finally to fully mature and complete. For that reason it is thought best to defer any particular recommendations for the present.

It is proposed to prepare a schedule of the terms in actual living use in encephalic nomenclature, giving equivalents in English, Latin, French, Italian and German, with a general indication of the principal authorities which use each. Thus may be estimated the relative weight of authority which each term may have. From this as a basis, recommendations can be made as to terms which should be discarded or modified; and the exact bearing which any new terms may have upon those which remain can be noted. It is hoped in this way to correlate the nomenclature without doing violence to it and without introducing crude or unacceptable novelties.

Frank Baker,
H. F. Osborn.
Members of Committee present.

SECTION A.

MATHEMATICS AND ASTRONOMY.

OFFICERS OF SECTION A.

Vice President.

J. R. EASTMAN[1] of Washington.

Secretary.

HENRY M. PAUL of Washington.

Member of Council.

HENRY FARQUHAR of Washington.

Members of Sectional Committee.

G. W. HOUGH of Chicago, ORMOND STONE of Univ. of Virginia,
C. L. DOOLITTLE of Bethlehem.

Member of Nominating Committee.

R. S. WOODWARD of Washington.

Members of Sub-committee on Nominations.

C. H. ROCKWELL of Tarrytown, C. G. ROCKWOOD of Princeton,
E. L. LARKIN of New Windsor.

[1] To fill vacancy caused by the absence of WILLIAM FERRELL.

PAPERS READ.

ON A METHOD OF COMPUTING THE SECULAR CONTRACTION OF THE EARTH. By R. S. WOODWARD, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

THE nature and difficulties of the problem are first set forth.

The method is based on four assumptions, viz.: 1. An initial uniform temperature for the earth's mass; 2. A constant coëfficient of diffusion for that mass; 3. The sufficiency of the first approximation to the roots of Fourier's transcendental equation; 4. A constant coëfficient of cubical contraction. The grounds for these assumptions are discussed and the desirability of certain experimental information indicated.

The main features of the mathematical work are explained and their correctness tested. The resulting expression for the contraction is given two principal forms, the one applicable to the earlier and the other to the later stages of cooling.

Some numerical results dependent on Sir Wm. Thomson's coëfficient of diffusion are given.

A COMPLETED NOMENCLATURE FOR THE PRINCIPAL ROULETTES. By Prof. F. N. WILLSON, Princeton, N. J.

[ABSTRACT.]

THE paper discusses the anomalies of both early and recent definitions of trochoidal curves; demonstrates, kinematically, the property of double generation of all epi- and hypo-cycloids and trochoids, establishing the identity of curtate and prolate forms; shows the inadequacy of the existing nomenclature to suggest the mode of generation of all curves of this class, and presents the following completed nomenclature in a tabular form (see next page) suggested by that of Kennedy, and of which it is both a modification and extension. The last three columns are the new and completing feature.

The demonstrations above alluded to establish the identity of the curves whose names are preceded, in the following table, by the same letter.

TROCHOIDS.

Position of Tracing or Describing Point.	Circle rolling upon Straight Line.	Circle rolling upon circle.				
		External Contact.	Internal Contact.			
			Larger circle rolling.	Smaller circle rolling.		
				$2R > F$*	$2R < F$*	$2R = F$*
	Linear Trochoids.	Epitrochoids.	Peritrochoids.	Major Hypotrochoids.	Minor Hypotrochoids.	Medial Hypotrochoids.
On Circumference of rolling circle.	Cycloid.	(a) Epicycloid.	(a) Pericycloid.	(d) Major Hypocycloid.	(d) Minor Hypocycloid.	Straight Hypocycloid.
Within Circumference.	Prolate Trochoid.	(b) Prolate Epitrochoid.	(c) Prolate Peritrochoid.	(e) Major Prolate Hypotrochoid.	(f) Minor Prolate Hypotrochoid.	(g) Prolate Elliptical Hypotrochoid.
Without Circumference.	Curtate Trochoid.	(c) Curtate Epitrochoid.	(b) Curtate Peritrochoid.	(f) Major Curtate Hypotrochoid.	(e) Minor Curtate Hypotrochoid.	(g) Curtate Elliptical Hypotrochoid.

* R = radius of rolling circle, F of fixed circle.

STANDARD DIMENSIONS IN ASTRONOMICAL AND PHYSICAL INSTRUMENTS. By J. A. BRASHEAR, Allegheny, Pa.

IN a paper read before the Franklin Institute by Mr. George M. Bond, the present secretary of Section D, the following words were quoted from Mr. Forney's report to the Master Car Builders' Association, on standard bolts and nuts:

"It is worthy of note that a remedy for the evil complained of by the Master Car Builders, that nuts, made by some firms, would not screw on bolts made by other firms, at first baffled the ability of the most prominent manufacturers of tools in the country, and to provide an adequate remedy it was necessary to secure the assistance of the highest scientific ability in the country, which was supplied through the coöperation of the professor of astronomy of the oldest and most noted institution of learning in the land. The man of science turned his attention from the planets and the measurements counted by millions of miles, to listen to the imprecation perhaps of the humble car repairer, lying on his back and swearing because a 5-8 nut a trifle small would not screw on a bolt a trifle large."

We all know this professor of astronomy and the noble work he has done in the way of giving us standards of the highest accuracy, which in turn have been carried out into practical mechanism by some of the honored members of the American Association, especially by Mr. Bond of the mechanical section.

Paradoxical as it may seem, though the astronomer has furnished the most accurate standards for the mechanician, thus facilitating the construction of interchangeable machinery all over the world, the astronomer himself has yet to put up with an eye-piece that is just a little too large for a sliding tube that is just a little too small; or, in other words, that branch of science, which has furnished the standard for all other work, is without any standard for the construction of its own instruments.

How many of the parts of an astronomical or physical instrument should be made interchangeable, I am not now willing to say, but every worker with the telescope, spectroscope, or other instrument for physical research, will bear me out in this fact: that there is a sore need of standard dimensions in many of the parts of our apparatus. Indeed, our president, Professor Langley, was one of the very first to call my attention to the matter, and suggested that it would be a very excellent plan for this Association to appoint a committee to discuss, and, if possible, decide upon some standard dimensions of the more important parts which should at the earliest date be made interchangeable. I might urge many reasons in support of standard dimensions in many of the parts of our astronomical and physical instruments, but it is not necessary, as the day has passed when we are satisfied with anything but interchangeable parts in modern machinery; therefore we should not be satisfied with anything less for our astronomical and physical instruments.

As an illustration of what is needed, I have constructed four spectroscopes within the past year for six inch aperture telescopes. The diameter of the tail piece of these telescopes has varied from two and one-half

inches to six inches, requiring a new pattern to be made for every clamp that holds the spectroscope to the telescope.

We have indeed only to look at the great variety of eye-pieces and their varied diameters for which we are constantly called upon to make adapters, so that they may be used with any degree of pleasure, to see how far we are from the ideal astronomical or physical instrument. We shall, in all probability, have to call to our assistance the "mandrel drawn" tube makers to give us standard tubes; and perhaps the founder to give us a standard metal, but we should make a move in the matter, and everything will come out right. These very mechanicians, to whom the astronomer has furnished the data, have given us standard reamers, standard gauges, and every facility for making our own work standard, and so we are without a subterfuge, without a valid excuse for doing our work in a "haphazard" way.

I should hope that whatever parts of our instrument we make of standard dimensions, that the basis should be a decimal system, preferably the metric; indeed, is it not possible that these standards might be made international, as they should most surely be? The greater then the value of the metric basis.

This paper is only suggestive, but I trust will serve to call attention to a fault in the construction of our apparatus that is not in accord with the progress in other lines of mechanical art.

THE PHENOMENA OF SOLAR-VORTICES. By Prof. FRANK H. BIGELOW, Racine, Wis.

[ABSTRACT.]

THE theory of the sun-spots as vortex rings admits certain tests which are here indicated. The spots are supposed to originate in the following manner:—the sun is composed of an ellipsoidal nucleus of viscous material with a figure corresponding to the period of rotation; surrounding this is a convectional region filled with currents of radiated gases and surmounted at the end of the cooling radius by a spherical envelope of condensation. The low specific gravity of the sun, the invariability of its apparent diameters under rotation, the acceleration of the equatorial belts point to this conclusion. The general contraction of the nucleus and other causes of constriction produce great bubbles all over its surface, but most vigorously near parallels of structural weakness where the tangential tension on the surface is a maximum. The escape of the gases occurs in the form of vortex rings which finally impinge upon the envelope, the strongest being able to break through. The spot belts and their periodicity depend upon the special energies of the nucleus.

Spots are distinguished as of the normal type and of the irregular forms. Each spot passes through three stages: the formation, the quiescence and the degeneration. The natural development of a vortex is that ordinarily observed, an apparition with local disturbance of the surface, including a lifted space gradually streaked with cleavages; the appearance of the true ring, umbra, penumbra and photosphore, with their respective

temperatures, accompanied by the formation of segments as the motions of translation and rotation become exhausted; finally the breaking up with ragged intrusion of the surrounding matter into the cavity thus produced. There is a double tendency, first of upward ascending currents till the vortex motion vanishes, and second of inward descending currents while the broken surface is being replaced. The middle stage is of quiescence or non-activity while the forces are in approximate equilibrium. The two types and the three classes of spots are only temporary modes of partial formation. From the time of appearance to the end of quiescence, when the direction of the movement changes, is the opportunity to study the vortex phenomena.

We present some proofs of this conclusion. 1. The motion in the spots is known to be upwards, conflicting or quiescent, and downwards by turns, on spectroscopic evidence. Currents of great velocity passing through an opening always assume a cyclonic rotation, if they act as a continuous stream. The stream-current theory is inadmissible since no strong circular motion is observed, nor is there sufficient accumulation of material at the place to allow for the vast quantity of fresh substances implied in such currents. The only alternative to tangential vortices is that of radial vortices or rings. 2. The formation of filamentary sections in planes intersecting at the centre of the vortex, and following the law that the product of the angular velocity into the section-area is a constant all around the ring, is apparently followed in the sun-spots. At this point accurate measures of the velocities and sections of the penumbra are needed for verification. The interchange of the relative section-areas is exemplified constantly; the persistence of the direction of the filament planes of rotation towards the original origin under the stress of distorting forces is a very obvious feature; the direction of the bridges, the direction of the filaments in the queues have the same meaning.

In order to measure the position and area of the sections at different epochs so as to render the results comparable, it is necessary to introduce such coördinates as can be referred to the fundamental plane determined by the observer's line of sight. Those proposed are: x-axis the tangent to the solar parallel passing through the centre of the vortex, positive eastward; y-axis the solar meridian, positive northward; and the z-axis normal to plane of vortex, positive outward. A series of general formulæ for tabulating the position of the x-axis and the y-axis depending upon the sun's longitude were given. The actual measurements must be reduced to the unit-measures on the plane of reference, and formulæ for the axis-foreshortening were produced.

Practical work upon the spots should have in view the successive areas of the sections, taken as consecutively as possible at short enough intervals to trace accurately the changes as they take place in the same section. The photographic methods may furnish a resource for overcoming the inherent difficulties, if pictures can be taken showing a sufficient number of details on the spot. It is also suggested that the study of vortex-rings on a large scale, as found in some volcanic regions, will supplement the mathematical theory with certain empirical constants needed in the applications to the solar-vortices.

THE GEOMETRIC MEANING OF SINGULAR SOLUTIONS OF DIFFERENTIAL EQUATIONS OF THE SECOND AND HIGHER ORDERS. By Prof. HENRY B. FINE, Princeton, N. J.

[ABSTRACT.]

DIFFERENTIAL equations generally have no singular solutions. For their occurrence in the case of the equation of the second order, it is necessary that there exist such relations among the coëfficients of $F\left(\frac{d^2y}{dx^2}, \frac{dy}{dx}, y, x\right) = o$ that the complete primitive $\phi\ (x,\ y,\ \alpha,\ \beta) = o$ be continuous function of x, y, α, β in a finite portion of the plane. On this hypothesis, $\phi\ (x,\ y,\ \alpha,\ \beta) = o$ represents a doubly infinite system of curves, algebraic or transcendental. Investigation shows that the relation holding between the coördinates of the point where any particular curve of the system $\phi = o$ is met by a consecutive curve $\phi + \frac{\delta\phi}{\delta s}\,dx + \frac{\delta\phi}{\delta\beta}\,d\beta = o$ which *touches* it, and the slope of the common tangent at this point—let this relation be called $X\left(\frac{dy}{dx}, y, x\right) = o$—is to be got by elimination of α and β between $\phi = o$, $\frac{d\phi}{dx} = o$ and $\begin{vmatrix} \frac{\delta\phi}{\delta s} & \frac{\delta\phi}{\delta\beta} \\ \frac{\delta}{\delta x}\left(\frac{\delta\phi}{\delta s}\right) & \frac{\delta}{\delta x}\left(\frac{\delta\phi}{\delta\beta}\right) \end{vmatrix} = o$, and is therefore the singular solution.

The theorem readily follows:—

The singular solution of a differential equation of the second order is a singly infinite system of curves, each of which has at every one of its points double contact with a particular curve of the doubly infinite system constituting the complete primitive.

The demonstration and consequent theorem readily admit of extension to differential equations of higher orders.

ON THE VISIBILITY OF OBJECTS AS CONDITIONED BY THEIR MAGNITUDE AND BRIGHTNESS, WITH APPLICATIONS TO THE THEORY OF TELESCOPES By Prof. WM. HARKNESS, Washington, D. C.

[ABSTRACT.]

IN this paper a series of experiments with Snellen's and other test-type were described, from which it was deduced that if v is the visual angle necessary to render the type legible when so illuminated that their brightness is b, then the relation between v and b is expressed by the equation

$$b\ (v - 3.62') = 1.38$$

where v is to be taken in minutes of arc, and the unit of brightness is ordinary day-light sufficiently intense to cause the pupil of the eye to contract to a diameter of about one-tenth of an inch. This definition may seem rather vague, but it is not really so because within pretty wide limit

of illumination the automatic action of the iris reduces the visual brightness of objects to a nearly invariable standard. In the experiments from which the formula was deduced, the brightness ranged from unity to about 0.0018; and, as at the latter brightness, the pupil of the eye would be expanded to a diameter approximating 0.24 of an inch (when it would admit 5.76 times more light than with a diameter of 0.10 of an inch) the experiments really covered all degrees of illumination from unity to about 0.0002—which seems to be the entire range of human vision.

After the derivation of the formula had been explained, it was applied to the general theory of telescopes, including night glasses, and it was shown that the maximum visibility of faintly illuminated objects is obtained when the telescope employed has a clear aperture in inches equal to one-quarter of its magnifying power, and the power is just sufficient to give the particular object observed, an apparent visual angle of about ten degrees. Among the phenomena explained was Herschel's famous experiment of reading the time from the dial of a distant church steeple by means of a large telescope when the darkness was such that the steeple itself was invisible to the naked eye. Incidentally, a simple and accurate method of measuring the diameter of the pupil of the eye in almost complete darkness was described.

PHOTOMETRIC OBSERVATIONS OF ASTEROIDS. By HENRY M. PARKHURST, New York, N. Y.

[ABSTRACT.]

INDIVIDUAL stars not reliable as photometric standards.

Their changes of brightness cannot be safely predicted.

Asteroids are liable only to certain changes which can be ascertained and predicted. Practically the principal change, after reducing to distance unity, is connected with phase. This varies in amount with different asteroids.

Usually the correction for rotation is so small that it is merged in the irregularities of the sky and the errors of observation. Remarkable exception.

Results of observations of Vesta, as compared with those of Professors Pickering and Harrington, after correction for phase.

Proof that the change in solar illumination at the present time is imperceptible.

MOMENT OF INERTIA. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

THIS paper called attention to a difference in the definition of the term "Moment of Inertia" by which, in some cases, all reference to mass is omitted. The necessity of a clear and consistent definition for students

of mechanics was insisted upon and some difficulties referred to arising from definitions of the term which omit the mass. A simple apparatus was described which was devised by the author for use in determining the moment of inertia of any body before a class or in practical work and the advantage of thus giving to students as concrete an idea as possible of moment of inertia was urged.

ON THE ECCENTRICITIES OF GUESSING. By Prof. T. C. MENDENHALL, Terre Haute, Indiana.

[ABSTRACT.]

A SERIES of about seven thousand guesses on the number of nails in a carboy was analyzed, the results grouped by hundreds and a chart showing their distribution was constructed. The resulting line showed some resemblance to the probability curve.

ON THE ORBIT OF HYPERION. By Prof. ORMOND STONE, University of Virginia.

ON THE HORIZONTAL FLEXURE OF A MERIDIAN CIRCLE. By J. M. SCHAEBERLE, Observatory, Ann Arbor, Mich.

VARIATION OF PERSONAL EQUATION: A CRITICISM. By HENRY FARQUHAR, U. S. Coast Survey Office, Washington, D. C.

THE EFFECT OF SOME PECULIARITIES OF PERSONAL EQUATION. By Prof. J. R. EASTMAN, U. S. Naval Observatory, Washington, D. C.

A LIST OF STARS WITH LARGE PROPER MOTIONS. By Prof. LEWIS BOSS, Dudley Observatory, Albany, N. Y.

THE LOGICAL THEOREMS REQUIRED IN ELEMENTARY GEOMETRY. By Prof. A. MACFARLANE, University of Texas, Austin, Texas.

THE LOGICAL FORM OF GEOMETRICAL THEOREMS. By Prof. A. MACFARLANE, University of Texas, Austin, Texas.

A NEW FORM OF "COMET SEEKER." By J. A. BRASHEAR, Allegheny, Pa.

METHOD OF PREVENTING BREAKAGE IN THE POLARIZING HELIOSCOPE. By J. A. BRASHEAR, Allegheny, Pa.

COËFFICIENTS OF COLLIMATION AND FLEXURE OF TRANSIT INSTRUMENTS WITH BROKEN TUBES. By Prof. JEFFERSON E. KERSHNER, Lancaster, Pa.

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ADDRESS

BY

PROFESSOR W. A. ANTHONY,

VICE PRESIDENT, SECTION B.

THIS is an Association for the Advancement of Science and the aim of its meetings has been to foster scientific research by affording, at least, opportunity for reports in the form of scientific papers upon the work accomplished by individual members, and for that general discussion and exchange of thought that so much aid scientific progress. With the same view, I suppose, it is decreed, that "the Vice Presidents shall be the chairmen of their respective sections, ... and it shall be a part of their duty to give an address each before his own section at such time as the Standing Committee shall determine." This rule compels me to ask your attention, for a brief period, while I add my mite to the promotion of the object of our meeting.

In 1883, your chairman gave you "A Plea for Pure Science." He pointed out to you the noble, self-sacrificing labors of those who have worked in the field of science for the purpose of discovering nature's secrets, and with no hope of pecuniary reward. He deplored the utilitarian tendency of our age and especially of our nation. He urged the importance of the study of science for the sake of science, and urged those occupying professors' chairs to give the time they could spare from their duties to scientific investigations instead of to commercial and expert work. We can all agree with him in admiration of the disinterestedness and self-sacrifice of the greatest scientific workers. We can agree with him that the grandest scientific problems, the determination of the constitution of matter, of the origin of the forces we are daily using, of the hidden relation between the different forms of en-

ergy, will never attract the utilitarian workers, and must be solved, if solved at all, by those who work for the love of science, without hope of pecuniary reward. But we must not forget that there is much in science that has a pecuniary value and that there will be a hundred workers with the less noble motive, where there is one who has no thought of pecuniary gain. It does not do to say that these workers are only promoting the application of science. "Science," says Herbert Spencer, is "classified knowledge," and he who adds a new fact to an already recognized class, or who develops new relations between phenomena, enabling us to predict results which before could only be arrived at by means of experiment, is advancing science, even though all were done in the pursuit of gain. The work done is the same, whatever the motive that led to the doing. It is my purpose in this address to point out some of the good accomplished by the utilitarian workers and to consider what may be done to render such work more effective in producing results of scientific value.

Many of those recognized as our foremost scientific workers have not given freely of all their work to the world. I find, in looking over the patent records the names of Sir William Thomson, Warren de la Rue, and other physicists, who have applied to the patent office for protection in the use of what they have discovered. Sir William Thomson, under date of February 20, 1858, claims the fall of potential method of testing for insulation, as the specifications have it, "by communicating a charge of electricity to it [a telegraph wire] and then leaving both ends insulated and some part of it connected by a conductor with an instrument for electro-static potential." Also by comparing its resistance to the flow of electricity from a constant source, with the resistance of a standard coil to the flow of electricity from the same or other constant source; the test of a submarine telegraph wire while laying it, the indicator of the galvanometer being suspended "by a stretched fibre passing through its centre of gravity;" the use of "a double bifilar suspension for the indicator of any electrometer, galvanometer, relay," or other testing instruments; using the suspending filament as a conductor, or conducting the electricity to the suspended body by means of a wire dipping in a conducting liquid; the use of thermal effects for recording telegraph signals; the use of photography for the same purpose. He claims also a method of transmitting messages between one

or "more conductors and a different number of conductors:" "several sending keys in branches connected to one cable are locked so that they can be used only one at a time and successively in a certain order;" "at the receiving station the letters must be read off and allotted to words in the same order,"—a system of multiplex telegraphy that does not seem to have been very generally adopted. In 1860 he patents "a form of Daniel's battery, in which the two liquids are connected by a siphon;" also the trough battery. In 1867 he patents an induction machine, in which metal carriers, attached to the rim of a vulcanite wheel, touch lightly as the wheel revolves upon springs attached to conductors. In these we recognize some of the best known instruments and methods of the physical laboratory.

In later years, Professor S. P. Thompson and Professors Ayrton and Perry have patented improvements in telephones, electric measuring instruments, etc. In this country, without multiplying examples, we find that Professor Mayer, of Hoboken, has patented a "topophone," and that Professor Rowland, of Baltimore, has patented a method of casting metals and a method of grinding screws. No one considers that the scientific work of Sir William Thomson and the others named is of less value because they have tried to reap from it the pecuniary harvest that it should legitimately yield. If the pursuit of wealth were to absorb all their powers, if the pursuit of science had no charm for them, except as it gave promise of pecuniary reward, then indeed we should have cause to mourn.

On the other hand, we have cause to be thankful for the contributions to science by men who have devoted their lives to commercial pursuits. Dr. Werner Siemens, of Berlin, and Charles Siemens, of London, have from time to time made most valuable contributions to our knowledge. They gave us the shuttle armature for the magneto-electro machine. Wilde, another business man, showed us how enormously powerful machines, which were the wonder of their time, could be made by using the current from a small Siemens armature to energize a large electro-magnet between the poles of which a second, larger Siemens armature, was made to rotate. Siemens then showed us the regenerative principle applied to the electro-magnetic machine and paved the way for the modern dynamo. His paper describing this was presented to the Royal Society, February 4, 1866, and he was allowed a patent for

it January 31, 1867. The description in the patent, which is almost the same as in the Royal Society paper, is as follows:

"In the electro-magnetic apparatus which carries out the method of this invention, rotary motion is imparted to the armature in the opposite direction to that in which it would move consequent on an electric current passing round the electro-magnets, and a galvanic battery being momentarily inserted into the system, or a magnetic impulse being imparted in any other way to the arrangement during rotation, an increasing electric current is developed in the coils which soon becomes a powerful current available for practical purposes." It will be seen that this contains the complete statement of the reversibility of the electric motor which Paccionotti only failed to enunciate because he did not know that his machine as a generator could be made to magnetize itself.

The work of Hopkinson and of Kapp, in developing the methods for predetermining the characteristics of a dynamo, is important scientific as well as practical work. Hopkinson has also advanced our knowledge of the theory of alternating currents, and has shown how to take account of the difference of phase between the waves of E. M. F. and current, in experiments to determine the energy developed. Elihu Thomson has shown that in consequence of the lagging of the waves of an induced current, the secondary coil of an induction system is always repelled by its primary, and he has constructed measuring instruments and alternating current motors based on this fact. Hundreds of other instances might be cited, of substantial contributions to science by men engaged in commercial pursuits, not only men like Siemens, Froelich and Hopkinson who have had a scientific training, but others, without such training, have by intuition or good fortune, while groping in the dark, discovered treasures that were hidden to those who carried the light of science. It is inevitable that much that is of scientific value must be done by such men.

This is the age of invention. One has only to look at the library shelves containing the publications of the patent office to see how very rapidly inventions and, presumably, inventors, have multiplied. If we measure the yearly volumes of the index to the names of patentees, we find in those from our own and from the British patent offices, a continued increase in thickness which since 1882 has been very rapid. This may look like measuring the growth of inventions by a foot rule, but I believe it is a fair in-

dication of what is going on in that direction, and, if inventions multiply in the next ten years in the same increasing ratio that they have in the last five, it will be necessary to use some such summary process to obtain any general view of the subject. An examination shows that the great increase in the number of patents in the last few years is largely due to the rapid progress of inventions involving applications of electrical science. In this direction alone, inventions and inventors are numbered by the hundred, and it is lamentable to see in how many cases supposed inventions are based on totally erroneous ideas, and in how few cases the inventor is guided by scientific knowledge.

Now I consider that every new thing, involving the application of scientific principles or truths, is a distinct advance in science itself. We knew before the days of Watt of the pressure of steam and of the power to be obtained by its condensation, but would any one dare to say that scientific knowledge has not been advanced through Watt's invention? Faraday has taught us the general facts of current induction, but was it not a step forward when Wilde showed us that by using the current from a small magneto machine to excite an electro magnet, the effects of the little magneto could be multiplied many-fold? And did not science move forward another step when Siemens showed us the regeneration of the magnetism of soft iron by means of the current developed through its own agency? And was there not a little advance when Bell showed us that the little currents developed by the infinitesimal vibrations of an iron plate in a magnetic field were capable of exciting in another plate in a distant instrument, similar vibrations that the ear could translate into spoken words? Can we say that all these uses of magneto-electric induction were included in Faraday's discovery and that these are obvious applications that in no way help the cause of science? No. Science acknowledges the debt it owes to men like Watt, Stephenson, Siemens and a host of others, who, in developing the applications of science, have brought to view new facts or presented to us old facts in a new light. And if the army of would-be inventors could enter the field with a full knowledge of what science has already done, the conquest of new territory would be still more rapidly accomplished, and not a few of those whose names would be remembered, would be found to have come up from the utilitarian ranks. And this brings me to the question which is the real subject of

this address, What can be done to render the work of those engaged in commercial pursuits more useful to science?

It is of the highest importance in a scientific point of view as well as from the point of view of progress in material wealth, that the principles and details of science should be spread broadcast. The grand truths of physical science should be the familiar talk of every school boy. Such doctrines as the conservation of energy should be inculcated by pointing out in the lowest schools the significance of familiar facts. Not only boys but girls should receive such training in order that the great truths of nature may become the heritage of future generations and be taught to the child from his earliest infancy. Very young children can appreciate the principles of physical science. I have in mind now a little boy of five years whom I have met this summer, whose father has a mill and machinery in operation, and whose mother is one of those rare women, gifted with a natural insight into physical laws. Partly by being about the mill, but mainly by his mother's teaching, this boy has learned the principle of the advantage gained by the lever; he knows how to reeve a pair of pulley blocks, and knows that the greater the advantage gained, the longer it takes to raise a weight. He knows that the pressure produced by a head of water is greater the larger the area pressed; and though he could not formulate the law of equivalence of energy, he *feels* that equivalence between the energy he expends on the long end of the lever and the work he accomplishes at the short end. This shows how, with natural gifts and proper early training, even a very young child may acquire a working knowledge of physical principles, and it is evident that a properly conducted education in the schools would develop from such a child a man who, if he should turn his attention to pure science, or to inventions in applied science, would avoid the mistake of trying to accomplish the impossible. With such an education for both boys and girls the number of such workers would increase, and each generation would furnish more and more material out of which such men could be made. What can our schools do to help in this education? Science now has but small place in the lower schools, and, when the matter of finding a place for it is broached, it is claimed there is no time. But how is the time of the pupils occupied? Besides the reading and writing, arithmetic, grammar, and geography have the most prominent places. Children of ten or twelve years are expected to

recite glibly the rules of grammar and to know the locality, and, perhaps, the number of inhabitants and chief products of twenty to a hundred towns in each state of the Union. I remember how I, as a youngster, learned that "a verb is a word that expresses action, being or state." Action conveyed some definite idea to my mind, perhaps, but my idea of "being" came from the Sunday school, and of "state" from the geography. Then I learned that "the nominative governs the verb in person and number," or, as we recited it in concert, in loud voices, "the nomi'tive gov'ns the verb in person 'n' number." What the nominative was and how it governed, who the persons were and how many of them, were mysteries to us. Our ideas of government were derived mainly from a big ruler, with which, sometimes, formal punishment was administered in the shape of one, two, three, or four blows on the palm of the hand, but as often it startled us by coming down on our knuckles at most unexpected times. The study of grammar is well enough, but it should be one of the last subjects for the boy to take up. He should study language by reading authors, not by burdening his mind with rules that to him have no meaning, and can have none till he has become familiar with language by its use. A month at eighteen will do more to give a knowledge of grammar than a year at ten. A noted writer on English literature said to me, "Volumes have been written upon the use of the subjunctive mood; but what is the use of rules? one must *feel* the subjunctive mood in order to use it properly."

Geography should be taught to give familiarity with the use of maps, and to impart a knowledge of the form and size of the earth and the general form of the great divisions of land and water. Beyond this, the geography should be a book of reference. As soon require the child to learn the dictionary by heart as to learn the names and localities on the map of all the little capes and headlands, rivers and lakes, and cities and towns, with which the minds of little children have been burdened. Indeed, I should state it as a general rule that, in the study of any subject, facts should be taught to children only for use in subsequent studies, or to point out and enforce important principles. The same rule would apply to the applications of a subject. Except as they help to elucidate the subject, applications should be left to special schools or classes where professional training is the object. "Interest," "discount," "partial payments," etc., should be cut out of the arith-

metic and given as part of a business training. I well remember how I, as a boy of twelve or thirteen, puzzled over the "United States rule," the "Massachusetts rule" and the "Vermont rule," for partial payments, and how perfectly plain and simple these seemed to me ten years later, although I had had nothing to do with the subject in the meantime. At a "Regents' examination" in arithmetic some years ago, among the problems to be solved was one upon "partial payments." The solution was long and tedious, and, in a majority of cases, for that reason was omitted. At the next examination, a similar problem appeared among the first in the list of questions, and the pupils were informed that they must solve the problems *in their order*. It seemed to be the object to determine, not whether the boys and girls knew arithmetic, but whether they were qualified to take positions in banks or counting houses. If such purely technical matters are to be included in arithmetic, then every pupil in anatomy should be taught to set a bone or amputate a limb, every student of chemistry should learn calico printing, and every student of physics should learn to proportion a dynamo and lay out the wiring for an electric light plant.

Compared with these technical applications of arithmetic, these thousand and one rules of grammar, with all the exceptions, and these localities of the rivers and brooks, and towns and villages of Australia or Central Africa, the primary facts and principles of physics seem to me of transcendent importance in the education of the children. Their earliest experiences have to do with gravity, heat, light and sound; and harmonic motion begins to upset their little brains as they rock in the cradle. Never are they removed from the action of physical forces, forces upon which we depend for life and strength, as well as for our comforts and pleasures. What more important for the child to study? What can he study so intelligently and to so good purpose? Why should he go to the ends of the world to find some little village to name and learn its locality, when the name and locality teach no lesson except that such a village exists?

Let us then *make* a place for physical science in our lowest schools and give to every pupil, every boy and girl in the land, some knowledge of physical forces. Above all, let the lesson of conservation of energy be drawn from the various familiar cases of its transformation. Beginning with the lowest schools, the

study of physics should continue through the higher grades and into our colleges. In short, it should continue through the whole of a "general" education. Beyond that, it should be possible for any one who wishes to do so, to continue the study to the end of his college or university course. Having found a place for the study of physics in the primary schools, how shall it be taught? First, I should say, by calling attention to familiar facts and pointing out their significance. Why does a heavy body fall rapidly and a feather slowly? Why does wood float and iron sink in water? The significance of such facts can be brought out by resort to simple experiments. The pupil can feel the resistance of the air to the motion of a fan, and he can be shown that iron floats on mercury. The instruction should consist in directing the study of facts and things. If a book is used, everything should be verified by observation or experiment. Very simple apparatus, only, is needed to provide for such instruction. In the higher grades of schools more elaborate apparatus should be provided, and phenomena that can only be produced by experiment should be studied. Laws, like the laws of falling bodies, of the pendulum, Boyle's law, the law of expansion by heat and of reflection and refraction of light should be discussed, and illustrative problems given for solution. Up to this point, at least, physics should be taught to every child. Here, probably, a majority of children would leave school altogether, but the training they will have received will do much to elevate the general intelligence of the people of this country in regard to physical phenomena and laws. For pupils who continue through the high school and college, provision is now made for instruction in physics; and this, based upon such early training as I have suggested, could be made far more efficient than it is now. I do not know that I have made myself understood in this address. I feel convinced that we must depend for the rapid advancement of physical science upon the education of the masses. In this country, men devoted to science purely for the sake of science are and must be few in number. Few *can* devote their lives to work that promises no return except the satisfaction of adding to the sum of human knowledge. Very few have both the means and the inclination to do this. Most of us are dependent upon salaries, and a salary binds us to service which, unfortunately, does not, in this country, usually mean scientific research. Those who can devote themselves to research

can be trusted to embrace every opportunity to prepare themselves for the work and inform themselves of what has been done. The fields that give promise of pecuniary reward have, however, attracted men poorly prepared for the work they have undertaken. Without mathematical training, without a knowledge of what science has already accomplished, they have spent precious time and large sums of money in reaching results, which a little scientific study would have taught them in the beginning.

I consider that the organization of our schools is largely to blame for this state of things. Let us require that science, and especially physical science, shall be studied from the primary schools, and we shall soon find in the great army of utilitarian workers, in place of the very few who have done good work in the past, numbers of men fully qualified to begin at the farthest point reached by science and push their work into new fields. In promoting the applications of science, they will advance science itself. Even if no new facts were discovered, or new principles demonstrated, they would furnish to scientists new instruments and means of research. In another way commercial interests help science. With the hope of reaching remunerative results, experiments are tried by commercial companies on a scale and at an expense, that could not be compassed by the physicist. What results might be reached if such experiments were always directed by scientific knowledge! I think the importance of this matter a sufficient excuse for occupying your time with it. I have urged here the importance, from the point of view of pure science, of science-teaching in our common schools. As much, and perhaps more, might be said from the point of view of the material prosperity of the country. This Association has, therefore, every advantage in urging the question of science-teaching upon the school boards.

PAPERS READ.

MEASUREMENT OF SURFACE TENSION OF LIQUIDS. By Prof. W. F. MAGIE, Princeton, New Jersey.

[ABSTRACT.]

THE aims of the investigation here presented are: 1. To obtain accurate methods of measuring surface tension; 2. To compare the results derived from different methods with the view to determine whether or not the contact angle of a liquid with the solid which it wets is invariably zero. The plan of this comparison was presented to the section at the Buffalo meeting.

A method of measurement, which yields very consistent results, consists in measuring the distance between the lower surface of an air bubble formed under a large concave lens in the liquid, and the horizontal plane of greatest section of the bubble. The setting on that plane is made by setting upon the image of an illuminated slit reflected from the surface of the bubble at that part where the tangent is vertical. The setting on the lower surface is made by setting on the end of a pointer brought in contact with the under surface. This method is independent of the contact angle.

Another method devised consists of measurements similar to the preceding made upon a column of liquid lifted from the surface of the liquid by means of a vertically moving convex lens.

Measurements upon water were made by the first method and by a method described by the author in the Am. Jour. of Science, Vol. XXXI, March, 1886. The results for the capillary constant a^2 were respectively 15.28 and 15.13. These results differ by more than the probable error of either, and indicate a contact angle for water of 12° 22′. Using this value for the contact angle and the value of a^2 given by the first method, the value of a^2, that should be obtained from the ordinary method of measurement by the use of capillary tubes on the assumption that the contact angle is zero, was shown to be 14.90. The result usually given as actually measured is about 14.80.

For absolute alcohol, the first method gives $a^2 = 5.576$.

A method described by the author in Wied. An. xxv, 421, which is independent of the contact angle, gives $a^2 = 5.859$.

The second method which was used with water gives for alcohol $a^2 = 5.809$.

The ordinary method by the use of capillary tubes gives $a^2 = 5.805$.

There is no indication of a finite contact angle from these results.

The discrepancy of the value given by the first method from the others was probably due to the fact that the measurements made by it did not involve any prolonged exposure of the surface to the air.

DETERMINATION OF THE INVARIABILITY OF THE COËFFICIENTS OF EXPANSION OF BAILY'S METAL, OF JESSUP'S STEEL AND OF CHANCE AND SONS' GLASS BETWEEN THE LIMITS OF —3° AND +93° FAHRENHEIT. By Prof. WM. A. ROGERS, Waterville, Me.

[ABSTRACT.]

THE observations upon which the result announced in the title of this paper depends, extend from Dec. 18, 1886 to July 8, 1887. The yard was taken as the standard of comparison and the particular standards employed were: (*a*) a combined yard and meter, standard of 62.0° Fahr., upon Baily's metal, designated R_2; (*b*) a combined standard yard and meter upon a bar of Jessup's steel, designated R_3; (*c*) a combined yard and meter upon glass, graduated and investigated by the writer for the Standards' Department of the British Board of Trade and designated *G*. Comparisons were made with two yards upon this bar. The first, designated G_a, has defining lines about 2 mikrons in width and the second designated G_b, has defining lines about 5 mikrons in width. This glass was made by Chance & Sons in 1870 under a special order from the Standards' Department.

The comparisons are divided into groups of 20° each, and the plan of procedure was to obtain a sufficient number of comparisons in each series for a safe determination of the coëfficients of expansion from each series independently. The unknown errors of the thermometers are thus, to a certain extent, eliminated, since in the thermometers employed there are few departures from a scale of uniform corrections.

The observations have all been made near points of time in the day designated *the critical point of no variation of temperature.* Special pains have been taken to obtain an equal number of comparisons at points above and below this critical point. Advantage has been taken also of the few occasions in which a steady natural temperature was maintained for several hours at a time. A large share of the comparisons, however, were made about half an hour after sunrise. The critical point which occurs in the afternoon was found to be far less safe than that which occurs in the early morning.

The following are the general results obtained from the observations:

(*a*) *Independent results from each group of* 20°.

The results are given in divisions of the micrometer in which one division = .0567 μ.

Temperature = τ.	DIFF.	R_2-R_3	DIFF.	RELATIVE COEFF.	R_2-G_a	DIFF.	RELATIVE COEFF.	R_2-G_b	DIFF.	RELATIVE COEFF.
°	Div.	Div.	Div.	Div.	Div.	Div.	Div.	Div.	Div.	Div.
4.48		-366.8			—486.0			—467.8		
15.53	11.05	—298.1	68.7	6.22	—394.4	91.6	8.29	—374.8	93.0	8.42
26.05	10.52	—232.9	65.2	6.20	—308.2	86.2	8.19	—290.6	84.2	8.00
35.54	9.49	—174.7	58.2	6.13	—232.9	75.3	7.94	—213.4	77.2	8.14
45.18	9.64	—114.8	59.9	6.21	—159.5	73.4	7.61	—140.6	72.8	7.55
54.52	9.34	—55.8	59.0	6.32	—82.9	76.6	8.20	—64.0	76.6	8.20
64.94	10.42	+9.4	65.2	6.26	+4.7	87.6	8.41	+23.8	87.8	8.43
75.21	10 27	+73.3	63.9	6.22	+89.6	84.9	8.27	+108.1	84.3	8.21
85.09	9.88	+132.2	58.9	5.96	+167.2	77.6	7 85	+184.9	76.8	7.77
		Means	......	6.18			8.09			8.09

It will be seen from a comparison of the values of the coëfficients, that there is no evidence of either a systematic increase or diminution in the relative values between the bronze the steel and the glass. The approach to constancy is as near as could be expected, when the inevitable accidental errors of observation are taken into account.

(*b*) ***Results obtained from groups of ten comparisons and referred to the mean temperatures* 33.86° *and* 48.84°.**

In the following table the residuals Δ, for (R_2-R_3), (R_2-G_a) and $R^2-G_b)$ between the limits $\tau = 1.77°$ and $\tau = 54.47°$ are reduced to the mean temperature 33.86° by means of the provisional value of the relative coëfficient 6.17 div. for R_2-R_3 and of 8.09 div. for R_2-G. The values of Δ between the limits $\tau = 55.97°$ and $\tau = 90.69°$ are reduced to 73.84° by means of the same coëfficients.

The solution of the equations of condition formed from the results given above, gives the following results:

SERIES I.

Coëfficient between R_2 and R_3
$= -6.17 - 0.02 = -6.19$ div. $=$
$8.509\ \mu$.

Coëfficient between R_2 and G_a
$= -8.09 + .094 = -7.996$ div. $=$
$-4.533\ \mu$.

Coëfficient between R_2 and G_b
$= -8.09 + .088 = -8.002$ div. $=$
$-4.543\ \mu$.

SERIES II.

Coëfficient between R_2 and R_3
$= -6.17 + .095 = -6.075$ div. $=$
$-3.444\ \mu$.

Coëfficient between R_2 and G_a
$= -8.09 + .032 = -8.058$ div. $=$
-4.569μ.

Coëfficient between R_2 and G_b
$= -8.09 + .076 = -8.014$ div. $=$
-4.544μ.

The following value of the absolute coëfficients for R_2 is adopted, viz.: 17.17 μ for each degree centigrade for one meter = 8.722 μ for each degree Fahr. for one yard. Hence:

Coëff. of R_3 from Series I = 5.213 μ	Coëff. of G_a from Series I = 4.189μ
" " " " " II = 5.278 μ	" " " " " II = 4.153μ

Coëff. of G_b from Series I = 4.179μ
" " " " " II = 4.178μ

As far as these observations are concerned, *when combined in the manner indicated*, the steel bar shows a slight increase in the value of its coefficient with respect to R_2 for an increase of the temperature, while the glass bar shows a slight decrease. The difference in either case is less than the correction due to accidental errors of observation.

The solution of equations of conditions formed by combinations into groups of five values each, gives:

Relative coëff. bet. R_2 and R_3 = —6.17—0.033 = —6.203 div. = —3.517μ.
Relative coëff. bet. R_2 and G_a = —8.09—0.017 = —8.107 div. = —4.596μ.
Relative coëff. bet. R_2 and G_b = —8 09—0.014 = —8.104 div. = —4.595μ.

Hence for the absolute coëfficients we have:

R_3 = 5.205μ.
G_a = 4.126μ.
G_b = 4.127μ.

Converting to centigrade and from the yard to the meter as a unit we have:

R_3 = 10.246μ for one meter.
G_a = 7.427 μ for one yard.
G_b = 7.429 μ for one yard.

From the Proceedings of the American Microscopical Society for 1885, page 157, we find from observations made and published long before the present series was commenced (and from the Proceedings of the American Academy of Arts and Sciences for 1882, page 385) that:

The coëfficient of R_3 = 10.250 μ for one meter.
The coëfficient of G = 7.400 for one yard.

The verification of the constancy of the coëfficients for bronze, steel and glass, seems, therefore, to be completely established, not only as regards the temperature, but also as regards the age of the metals employed.

DETERMINATION OF THE COEFFICIENTS OF EXPANSION OF THE GLASS PLATES USED FOR STELLAR PHOTOGRAPHY AT CORDOBA IN THE YEARS 1872 TO 1875 AND 1879 TO 1883. By Prof. WM. A. ROGERS, Waterville, Me.

[ABSTRACT.]

THE following determination of the coëfficients of expansion of the glass plates used by Dr. Gould in his photographic observations at Cordoba depends on comparisons of a decimeter traced upon two specimens of the

glass sent to me for this investigation, with the following standards of length, viz:

(a) The first decimeter of my standard meter upon Baily's metal and designated R.

(b) The first decimeter upon my standard meter upon Jessup's steel designated R_3.

(c) The first decimeter upon a standard meter upon glass belonging to the Standards' Department of the British Board of Trade. It is designated G.

No pains were taken to make the transfers very exact inasmuch as the object was the determination of the law of expansion rather than the absolute lengths of the transfers.

The observations, sixty in number, extend from March 17 to July 10, 1887. An observation is to be understood as a comparison, consisting of eight readings, of the two decimeters upon the glass selected with the decimeters R_2, R and G. The values $R_2-(1)$, $R_3-(1)$, $G-(1)$, represent the difference in length between the decimeters R_2, R_3 and G, and the decimeter upon specimen number (1) which represents the kind and quality of glass used between 1872 and 1875. The residuals $R_2-(2)$, $R_3-(2)$, $G-(2)$, result from similar comparisons for the kind and quality of glass used in the series of photographs made in the years 1879 to 1883.

The following are the equations of condition formed by the substitution of the observed data in the equation,

$$\Delta = a + (62.0^\circ - \tau)\, b$$

in which

Δ = the observed values $R_2-(1)$, $R_3-(1)$, etc.

a = the difference in length between R_2 and (1), R_3 and (1), etc., at 62.0° Fahrenheit.

b = the relative coëfficient of expansion between (1) and the selected standard decimeters for each degree Fahrenheit.

The following normal equations result from the solution of six equations, each equation resulting from ten observations. The known terms are expressed in terms of divisions of the micrometer, the value of one division being 0.567a.

R_2 with (1)

$$\begin{aligned} 6\,a + 100.19\,b &= +325.2 \\ 100.19a + 4056.3\,b &= +3354.6 \\ b &= -0.087 \text{ div.} \\ a &= +68.7 \text{ div.} \end{aligned}$$

R_2 with (2)

$$\begin{aligned} 6\,a + 100.19\,b &= +183.9 \\ 100.19a + 4056.3\,b &= +122.2 \\ b &= 0.902 \text{ div.} \\ a &= +45.7 \end{aligned}$$

R_3 with (1)

. . . + 390.3
. . . + 5972.1
. . . = — 0.233 div.
. . . = + 69.1 div.

R_3 with (2)

. . . + 250.1
. . . + 3494.9
. . . — 0.286 div.
. . . + 48.5

G with (1)

. . . + 278.4
. . . + 4582.9
. . . — 0.028 div.
. . . + 46.7 div.

G with (2)

. . . + 136.2
. . . + 2107.0
. . . — 0.072
. . . + 23.9

The following values have been adopted for the absolute coëfficients of R_2, R_3 and G, for each degree Fahrenheit and for the length of one decimeter. [See Proceedings of the American Microscopical Society for 1885, page 157, and Proceedings of the American Academy of Arts and Sciences for 1882, page 385.]

Coëfficient of R_2 one decimeter $= 0.954\ \mu$
Coëfficient of R_3 " " $= 0.570\ \mu$
Coëfficient of G " " $= 0.447\ \mu$

Giving to the comparisons with R_2 a weight of 1 and to those with R_3 and G a weight of 3 each, we have the following final results:

	Coëfficient of (1)	weight	Coëfficient of (2)	weight
From R_2	$0.460\ \mu$	1	$0.443\ \mu$	1
R_3	$0.438\ \mu$	3	0.408	3
G	$0.431\ \mu$	3	0.406	3

Adopted value of (1) $= 0.438\ \mu$. Adopted value of (2) $= 0.412\ \mu$.

A STUDY OF THIRTY-TWO MERCURIAL THERMOMETERS UNDER VARIATIONS OF TEMPERATURE BETWEEN THE LIMITS —29° AND +95° FAHRENHEIT. By Prof. WM. A. ROGERS, Waterville, Me.

[ABSTRACT.]

THIS investigation was undertaken for the purpose of establishing the real values of the corrections to be applied at very low temperatures. Thirty low temperature thermometers of the signal service pattern have

already been compared with the two sensitive standards belonging to the writer since January of the present year. The total number of comparisons thus far made is a little over 16,000. A large share of the comparisons have been made with the aid of a telescope of two inches aperture.

After the correction for calibration for each of these thermometers has been applied, it is expected that the mean correction for the entire series will contain only the error due to the departure of mercury from uniform expansion at very low temperatures. In order to ascertain the value of any correction of this kind which may exist, the changes in length of a column of mercury, one meter in length and having a nearly uniform diameter of seven tenths of a millimeter, will be determined for extreme variations of temperature.

It is expected that the series of observations undertaken will be completed in March, 1888.

A METHOD OF COMPARING GALVANOMETER COILS. By Dr. JOSEPH J. SKINNER, Mass. Inst. Technology, Boston, Mass.

[ABSTRACT.]

THE two coils to be compared are fastened together concentrically, and with their mean planes as nearly as can be judged coincident and in the meridian. A magnetic needle is hung in the common axis at a measured distance from a point of reference made by cross threads at the common centre of the coils. A divided current is sent through the coils in opposite directions, and a resistance in one branch is adjusted till the currents produce a null effect on the needle. The resistances of the coil circuits are then immediately measured. The rigidly connected coils, with the attached cross threads, are next turned through 180°, and the distance from the point of reference to the needle made exactly the same as before. The divided current is again adjusted to give a null effect on the needle, and the resistances of the coil circuits are again measured.

If the mean plane of a coil be defined as a plane such that at equal and large distances on each side of it in the axis, a magnet needle will be equally deflected, let x and y denote the small and unknown errors of position, or the distances from the respective mean planes of the coils to the assumed central point of reference, let R and N denote the mean radius and the number of turns of wire of the first coil, and r and n the corresponding quantities of the second, let C and c denote the currents in the respective coils in their first position, C' and c' the currents in the second position, and e the distance from the central point of reference to the needle; the paper deduces the following approximate equations:

$$\pi r^2 n =$$

$$\frac{\frac{C}{c}+\frac{C'}{c'}}{2} \cdot \pi R^2 N \frac{(e^2+r^2)^{\frac{3}{2}}}{(e^2+R^2)^{\frac{3}{2}}} \left\{1-\frac{3}{2}\cdot\frac{x^2}{e^2+R^2}-\frac{3}{2}\cdot\frac{e^2x^2}{(e^2+R^2)^2}+\frac{3}{2}\cdot\frac{y^2}{e^2+r^2}+\frac{3}{2}\cdot\frac{e^2y^2}{(e^2+r^2)^2}+\right.$$
$$\left.\frac{9e^2xy}{(e^2+R^2)(e^2+r^2)}\right\}. \qquad (9)$$

$$\frac{C}{c}-\frac{C'}{c'}=\frac{r^2 n\,(e^2+R^2)^{\frac{3}{2}}}{R^2 N\,(e^2+r^2)^{\frac{3}{2}}}\left\{\frac{6\,ex}{e^2+R^2}-\frac{6\,ey}{e^2+r^2}\right\}. \qquad (10)$$

When it is known that x and y are extremely small, the terms containing them can be dropped from equation (9). If R and N are known and r can be measured approximately, equation (9) then enables us to calculate the total area, $\pi r^2 n$, of one coil, in terms of the known elements of the other, first multiplying the right hand member of equation (9) by $\frac{Q}{q}$, where Q is the force-correction at the needle due to the section of the coil whose radius is R, and q the corresponding correction for the other coil. The *current* ratios are known from the measured resistances.

If x and y are large, it will be shown by a large observed value of the left hand member of equation (10). In this case equation (9), disregarding x and y, will still give an approximate value of $r^2 n$. A complete new set of observations is then made, with a different value of e. The results of the two sets of observations, substituted successively in equation (10), with the approximate values of r and $r^2 n$, give two equations of the first degree in x and y, from which these latter may be found, and, being known, they may be used in equation (9) to get a closer approximation to $\pi r^2 n$.

The paper shows that, if r is liable to uncertainty, rather large values of e are best for finding $\pi r^2 n$; also that even if r be liable to uncertainty, but if it be possible to measure e with sufficient accuracy, the value $e = r\frac{\sqrt{2}}{2}$ will be best for finding n.

The method is illustrated by an account of several sets of observations on a pair of coils in the Laboratory of the Mass. Institute of Technology.

A general formula is also given for finding the position of a plane between two parallel and co-axial coils of equal radius and unequal numbers of turns of wire in infinitely small sections, such that at equal distances on each side of the required plane the force on a needle in the common axis due to equal currents in the wire of the two coils, shall be equal. For values of the distance between the coils small compared to the radius the distance of the required plane from the half-way point between the coils is given as

$$\frac{b\,(n-m)}{n+m}.$$

in which b is the half-distance between the coils, and m and n are the numbers of turns of wire on the coils.

On the electromotive force of magnetization. By Dr. Edward L. Nichols and William S. Franklin, University of Kansas, Lawrence, Kans.

[ABSTRACT.]

If two electrodes of iron or steel be submerged in a liquid capable of dissolving iron and the free ends be connected metallically, permanent electric currents will be developed in the circuit thus formed whenever

the magnetic condition of the electrodes differs or whenever they are situated in magnetic fields of unequal intensity.

The electromotive force to which these currents are due we propose to call, for want of a better name, the *electromotive force of magnetization.* Two different, and we believe quite distinct, effects are comprised under this term.

Effect (*a*) is produced by magnetization of the electrode. To this effect it is not essential that the reaction between the iron and the liquid take place within the magnetic field.

Effect (*b*) occurs when the reaction takes place within the magnetic field. The currents due to effect (*a*) have already been investigated and described by Dr. Theodore Gross.[1] The study of the influence of magnetism upon the chemical behavior of iron has led the present authors to the discovery of the effect (*b*). A description of their investigations forms the substance of this paper.

A variety of experiments were tried to determine the conditions of the formation of these currents and the following points were established.[2]

(1). The E. M. F. developed when one of the electrodes is placed within a magnetic field is not principally due to structural change in the magnetized electrode.

(2). The E. M. F. under consideration is not that due to magnetization merely (effect *a*) but depends upon the reaction between the iron and liquid occurring within the magnetic field.

(3). The E. M. F. between the electrode within the field and that acted upon by the same liquid outside of the field varies with the liquid used from a very small quantity, much less than the one hundred thousandth of a volt to several hundredths of a volt.

(4). The E. M. F. increases as a rule with the strength of the electrolyte; *i. e.*, with the rapidity of the reaction.

(5). The E. M. F. is very much greater where the result of the reaction is a ferric salt than where a ferrous salt is formed.

(6). The E. M. F. increases with the strength of the field although not in direct proportion to the latter.

(7). The direction of the current depends upon the position (with reference to the induced poles in the electrode) of the portion of the latter exposed to the liquid. Portions of the surface located near the poles of the magnetized electrode become as *zinc* in their voltaic relation to the iron not within the field, whereas neutral regions between the induced poles tend to become as platinum to an electrode outside of the field.

(8). The E. M. F. depends upon the distance between the poles induced in the electrode. An experiment with two small bars of Norway iron of different lengths but equal in cross section, the bars being placed in turn parallel to the lines of force, the ends only exposed to the acid, showed the E. M. F. between the end of the bar and an electrode of similar iron outside of the field to be much greater for the longer bar (approx.

[1] Sitzungsberichte der Wiener Akademie Bd. 92, 1886.
[2] American Journal of Science, III, Vol. 31, p. 272, 1886.

imately proportional to the squares of the distances between the induced poles.

(9). The E. M. F. between an iron electrode and one of copper or platinum is modified, when the cell is placed within the magnetic field, in a manner similar to that between iron electrodes.

It follows from the above that when iron is acted upon by acids or other reagents in the magnetic field, local voltaic action will occur between those portions of the iron which become magnetic poles and the intermediate neutral parts, the poles becoming as *zinc* the neutral regions as *platinum*. To this local action are to be ascribed we believe those peculiarities of chemical action in the magnetic field which formed the subject of a recent paper, already cited. The power of magnetism to destroy the passivity of iron in nitric acid to which attention was called in that paper, and which we have since treated at greater length elsewhere,[3] is doubtless due to these local currents.

A METHOD OF TELEPHONIC COMMUNICATION BETWEEN SHIPS AT SEA. By Prof. LUCIEN I. BLAKE, Rose Poly. Inst., Terre Haute, Ind.

[ABSTRACT.]

IN February, 1883, while investigating, at Berlin, the experiments of Colladon and Sturm on the velocity of sound through Lake Geneva, the writer devised the following practical method of telephonic signalling between ships at sea. Actual experiment upon the method was begun upon return to the United States in June, 1883, and continued to the present time. In the method, as outlined in 1883, steamships were to be provided with steam sound-producing apparatus under water; the water would transmit the signals in all directions; specially devised microphonic transmitters attached under water to vessels were to connect with telephones within the vessels, and to take up the sound out of the water; the transmitters for protection were to be placed in tubes opening to the water near the keel, projecting up through the hull and plugged at their upper ends to prevent the flow of water into the vessel. Sailing craft, buoys, lighthouses, etc., were to be provided with bells under water; transmitters for small craft were to be cones, with membranes across their large ends, and with apices applied to the ear. Experiments were conducted on Taunton River and off Newport, R. I., in 1883; on Long Island Sound in 1884; on the Wabash River at Terre Haute, Indiana, in 1885–86–87. Signals were transmitted and received from submerged locomotive bells from one-half to one and one-half miles, and under varying conditions of weather and of the water. The first apparatus consisted of a modified Ader microphone for transmitter under water with Bell receiver in the vessel. With this, signals were received in 1883 from a boat one-half mile distant.

[3] Proceedings of the Kansas Academy of Sciences, 1885–86.

The next transmitter was simply a diaphragm in voltaic circuit with a Bell receiver. This diaphragm was made of carbon granules embedded in rubber cement. The diaphragm vibrations from the sound waves in the water produced varying pressures at the carbon contacts, which caused the undulatory current for the receiver. The next transmitters were constructed of a wooden diaphragm resting against buttons made of the above described carbon granulation in rubber or celluloid. These buttons were in voltaic circuit with an induction coil and Bell receiver. All these transmitters received sound clearly out of the water through varying distances up to one and one-half miles. Probably with a source of sound louder than a locomotive bell the distance would be greatly increased. At present larger diaphragms are being made and here the experiments rest.

EXPERIMENTAL DETERMINATION OF MINIMUM VELOCITY OF WIND IN THE WASHINGTON, OHIO, TORNADO. By Prof. C. LEO MEES, Athens, Ohio.

[ABSTRACT.]

STRAWS penetrated wood to a depth of $\frac{1}{32}'' - \frac{1}{16}''$ impelled by the force of the wind in the tornado. The phenomenon was reproduced in the laboratory by means of an air current and the velocity of the straws measured. Result 135–160 miles per hour.

CERTAIN PHENOMENA PRODUCED BY THE EXPLOSION OF GUN COTTON ON METALLIC PLATES. By Prof. CHARLES E. MUNROE, U. S. N., Torpedo Station, Newport, R. I.

[ABSTRACT.]

A description was given of the results obtained when gun cotton, upon which certain figures had been produced, was detonated on iron plates. Various experiments have been made to discover the cause of these phenomena and several theories have been suggested to account for them. The paper was illustrated by the exhibition of specimens.

THE SIMULTANEOUS MEASUREMENT OF THE SPEED OF AN ENGINE AND DYNAMO BY ELECTRICITY. By Prof. H. S. CARHART, Ann Arbor, Mich.

[ABSTRACT.]

THE apparatus employed is Cushing's so-called velocimeter. It consists of a time marker and a recorder. The first is a reed which vibrates one-hundred and fifty times per second and opens and closes an electric

circuit at every vibration. The recorder is a device for drawing a strip of sensitized paper between three iron points or pens and a metallic wheel. The pens are connected with the positive pole of a suitable battery and the wheel with the negative. One pen includes the reed and makes one-hundred and fifty blue marks per second on the paper. The circuits of the second and third are interrupted at every revolution of the engine and dynamo respectively. Hence the simple process of counting the blue marks gives the speed of both engine and dynamo; and if the diameters of the driving wheel and the pulley are known, it gives also the slip of the belt. Specimens of the record obtained with a Ball engine and a Thomson-Houston dynamo were exhibited.

A NEW DYNAMOMETER WITH WORKING MODEL. By Prof. J. BURKITT WEBB, Stevens Institute of Technology, Hoboken, N. J.

[ABSTRACT.]

THIS dynamometer is upon the same principle as the well known "Brackett Cradle" for the measurement of the power absorbed by a dynamo; it is, however, designed to avoid difficulties sometimes met with in the use of the same. The dynamometer consists of one or more tanks in which are floated an equal number of smaller tanks of such size that the total volume of water displaced shall equal in weight the dynamo to be experimented upon, plus the weight of the platform and other necessary parts including some movable weights, by which the position of the centre of gravity may be adjusted. These tanks are placed at the four corners of a platform upon which the dynamo stands near its centre, and their position with reference to each other and to the dynamo is so arranged that the equilibrium of the whole—dynamo, platform and floating tanks—about an axis perpendicular to the dynamo shaft is almost, if not quite, neutral; while about an axis parallel thereto, its stability is such as to give the amount of sensibility desired in the experiment.

In addition to controlling the stability by the position of the floating tanks, it may also be changed by placing weights either in the bottom or on top of the floating tanks, the stability being increased by the removal of weights from the top to the bottom. The adjustment of the centre of gravity of the floating mass in the same vertical as the "centre of buoyancy", when the platform is level, is made by the movement of weights on the platform, while the centre of the dynamo shaft is brought into the same vertical by moving the dynamo itself, the test of its coincidence with this vertical being that a weight hung upon the shaft shall produce no tilting of the platform. A vertical adjustment, to bring the dynamo shaft on the same level with the driving shaft is made by altering the amount of water in the outer tanks and, by means of accurate spirit levels placed upon the platform, this adjustment can be made with the greatest accu-

racy. The outer tanks are mutually connected with rubber hose so that the water may stand at the same level in all, the tanks so connected having, however, this advantage over one large tank and float, that oscillations are to a considerable extent prevented because the additional water displaced (technically the "wedge of immersion") by a tilting of the floating mass must flow slowly through the tubes to the opposite tanks. The tilting of the platform is measured by attaching a mirror thereto and observing with a telescope the reflection of a scale, or by means of a level attached to the platform; or the platform can be maintained level by a weight moved along a graduated scale beam attached to the platform, the position of which on the beam must of course be carefully noted in each experiment. This dynamometer allows the dynamo shaft to be coupled directly to a driving shaft or to be run by a belt from one side, in which latter case the pull of the belt must be opposed by a strut having journals in one end for the driving shaft and in the other for the dynamo shaft; the friction of these journals and the weight of this strut introduce no inaccuracies in the experiments. From the above description it will be seen that this dynamometer furnishes the needed support for the dynamo to be tested and no more, leaving it free to float into the correct position with respect to the driving shaft, and free on all sides for connection with the same either "in line" or by belt; at the same time its adjustments are made in the simplest manner and it is free from all friction, so that the most delicate indications may be expected from it.

[A full description of the two forms of this dynamometer — the "Floating Dynamometer with Floating Caissons" and the "Floating Dynamometer with submerged Caissons," will be found in the New York "Electrical World" for Sept. 10 and 17, 1887.]

THE ELECTRICAL CONDITION OF THE ATMOSPHERE IN FAIR WEATHER AND DURING A THUNDER STORM. By Prof. T. C. MENDENHALL and A. S. McRAE, Terre Haute, Ind.

[ABSTRACT.]

OBSERVATIONS with quadrant electrometer and water-dropping collector, covering a considerable number of days on which no clouds were visible, go to show that under such conditions the air is universally electrically positive. The very few exceptions in which negative electrification appeared for a moment or two are doubtless explainable as being due to accidental disturbances. The degree of electrification is tolerably constant during the day, with indications of a maximum in the morning. During the passage of a thunderstorm, however, the variations in potential are very marked and the changes often very rapid. In general, the air at first becomes negative and somewhat steadily so; but at the beginning of the fall of rain, violent fluctuations from low negative to high positive take place, and these generally continue until after the storm has passed, when

the potential generally becomes steadily positive. Potential as high as many thousands of volts are observed, accompanied by sparking in the apparatus. It appears that, in general, the appearance of negative potential is coincident with the appearance of rain, either at the station or near by. It cannot be said to *precede* the rain with certainty, although this sometimes happens.

ON A MAGNETIC BRIDGE OR BALANCE FOR MEASURING MAGNETIC CONDUCTIVITY. By Dr. THOMAS A. EDISON, Orange, New Jersey.

[ABSTRACT.]

PERHAPS no electric measuring instrument has proved more useful in practice, especially if we consider the various forms which it has assumed, than the device contrived by Christie and commonly known as Wheatstone's bridge. It was with the belief that a similar instrument could be constructed which should perform the same service for magnetic measurements, that the experiments were made the results of which I have the honor now to present to the Section.

The Wheatstone bridge is based upon the fact that if two points of different electric potentials are united by two conducting paths the fall of potential along these paths is absolutely the same provided that these paths are absolutely alike electrically. Consequently, if two points equidistant from the place of higher potential be connected together, no current will flow through the connecting wire. So, by analogy, if two points be maintained at a constant difference of magnetic potential, the fall of potential from one to the other through two or more paths will be absolutely uniform in all provided these paths be magnetically identical. Hence at any two points equidistant from a given terminal, the magnetic potential is the same and these points would be without differential action upon a magnetic pole.

The magnetic bridge may be constructed in the form of a rhomb, the typical form of the Wheatstone bridge. For this purpose the four sides are made of the purest Norway iron as soft as possible and thoroughly annealed. To the acute angles of the rhomb are connected the poles of a long U-shaped electromagnet whose function is to develop the desired magnetic potential-difference at these points. Connected to the two obtuse angles, and projecting inward, are two bars of Norway iron similar in section to those forming the sides. Their inner ends, which are hollowed out, approach to within about a half inch of each other. Between these ends a stirrup is suspended by means of a silk fibre, which stirrup carries a short needle consisting of a thin tube of hardened steel well magnetized. To the stirrup is attached either a pointer moving over a graduated arc, or better a mirror by means of which the deflection can be read in the usual way with a lampstand and scale.

In the instrument now in use in my laboratory the magnetic bridge is in the form of a rectangle, the ends or poles of the electromagnet being connected to the middle of the short sides, while the bars which pass inward to the needle are joined to the middle of the longer sides. The four halves of these longer sides constitute the sides of the bridge. The two at one end of the rectangle are fixed, the two at the other end are movable. The two bars which pass inward to the needle are curved so as to form a semicircle standing above the plane of the rectangle. The needle itself is similar in construction to that above described but is suspended by a wire attached to a torsion head. A photograph of this apparatus I have the pleasure of exhibiting to the section.

It will be readily seen that when the electromagnet is charged, a constant difference of magnetic potential is maintained at the two ends of the rectangle, so that if the four bars constituting the sides of the bridge are magnetically identical, there will be no difference of magnetic potential between the ends of the bars which pass to the needle and hence there will be no deflection. But if one of the movable bars be loosened, the needle is at once deflected, and in a direction depending upon the side the bar occupies. If the bar be entirely removed the deflection is a maximum of course. And if it be replaced by another bar differing in cross section, in quality of iron, or in any other way which affects the magnetic conductivity through the bridge, the deflection shows at once the amount of difference between that bar and the original one taken as a standard. The instrument is extraordinarily delicate and the principal difficulties encountered in using it have arisen in the attempt to preserve this delicacy while at the same time the range of the apparatus is maintained.

The magnetic bridge was devised for the purpose of testing readily the quality of the iron purchased for the construction of dynamos. Very great variations are observed in irons supposed commercially to be of the same quality. Consequently the potential difference developed by a dynamo having field cores of such iron can never be exactly calculated. But by comparing, in the magnetic bridge, the iron which is to be thus used, its exact value for dynamo purposes may be determined and the constants of the generator thus accurately calculated in advance.

But this bridge it would seem will be equally useful for testing iron and steel for other purposes. By its means not only may the character and quality of the metal be ascertained in terms of any desired standard, but flaws in the interior of a bar such as a car axle may be discovered at once.

Constructed with sufficient care and attention to details, the magnetic bridge may without doubt be made a most valuable instrument of precision for the furtherance of scientific research. The theory of its action is extremely simple and it is the exact counterpart of an ordinary Wheatstone bridge constructed for measuring low resistance and immersed in salt water, since now whatever is true electrically of the one is true magnetically of the other. Not only may the laws of magnetic conductivity be investigated by means of this balance for all para and diamagnetic bodies but the variation of this conductivity under the action of various physical

agencies such as heat, pressure, stress, etc., may be determined. It is in the belief that this instrument may contribute something to the advancement of electrical science and with the hope that it may do so, that I venture to bring it to the notice of my fellow members of the American Association.

ON THE PYROMAGNETIC DYNAMO: A MACHINE FOR PRODUCING ELECTRICITY DIRECTLY FROM FUEL. By Dr. THOMAS A. EDISON, Orange, New Jersey.

[ABSTRACT.]

THE production of electricity directly from coal is a problem which has occupied the closest attention of the ablest inventors for many years. Could the enormous energy latent in coal be made to appear as electric energy by means of a simple transforming apparatus which accomplishes its result with reasonable economy, it will be conceded probably that the mechanical methods of the entire world would be revolutionized thereby and that another of those grand steps of progress would be taken of which the nineteenth century so justly boasts.

The simple production of a potential difference by means of heat is as old as Seebeck and Melloni. The science of thermo-electricity thus originated has been developed by Becquerel, by Peltier, by Thomson and by Tait, and the thermo-batteries of Clamond and of Nöe have found many important practical uses. The results already attained in these generators have stimulated research marvellously, and many investigators have believed that in this direction lay the philosopher's stone. Our fellow member, Moses G. Farmer, worked long and assiduously in this field producing, it is believed, the most satisfactory results as regards economy which have ever been obtained; but even these results were not very encouraging. He never succeeded in converting one per cent of the energy of the coal into electric energy. Quite recently Lord Rayleigh has discussed with his well-known ability, the law of efficiency of the thermo-battery from the standpoint of the second law of thermodynamics, and he concludes that for a copper-iron couple, working between the extreme limits of temperature possible for these metals, a conversion of not more than one three-hundredth part of the coal energy can be hoped for. While, therefore, as a heat-engine the thermo-cell appears to follow precisely the law of Carnot and hence may have a theoretical maximum efficiency equal to that of the reversible engine of this eminent philosopher; yet, in practice, its efficiency falls very far below this theoretical maximum.

It therefore follows that if the result hoped for is to be attained at all, it must obviously be looked for in some other direction than in that of the thermo-cell. In considering the matter, another line of investigation suggested itself to me, the results of which I have the honor now to submit to my fellow members of the Physical section. It has long been known that the magnetism of the magnetic metals, and especially of iron, cobalt

and nickel is markedly affected by heat. According to Becquerel, nickel loses its power of being magnetized at 400°, iron at a cherry-red heat and cobalt at a white heat. Since, whenever a magnetic field varies in strength in the vicinity of a conductor a current is generated in that conductor, it occurred to me that by placing an iron core in a magnetic circuit and by varying the magnetizability of that core by varying its temperature, it would be possible to generate a current in a coil of wire surrounding this core. This idea constitutes the essential feature of the new generator, which therefore I have called a pyromagnetic generator of electricity.

The principle of utilizing the variation of magnetizability by heat as the basis of electric machines, though clearly applicable to generators, was first applied to the construction of a simple form of heat engine which I called a pyromagnetic motor.[1] A description of this motor will help us to understand the generator subsequently constructed.

Suppose a permanent magnet, having a bundle of small tubes made of thin iron placed between its poles and capable of rotation about an axis perpendicular to the plane of the magnet, after the fashion of an armature. Suppose, further, that by suitable means such as a blast or a draught, hot air can be made to pass through these tubes so as to raise them to redness. Suppose that by a flat screen symmetrically placed across the face of this bundle of tubes and covering one-half of them, access of the heated air to the tubes beneath it is prevented. Then it follows that if this screen be so adjusted that its ends are equidistant from the two legs of the magnet, the bundle of tubes will not rotate about the axis, since the cooler and magnetic portions of the tube-bundle (*i. e.*, those beneath the screen) will be equidistant from the poles and will be equally attracted on the two sides. But if the screen be turned about the axis of rotation, so that one of its ends is nearer one of the poles and the other nearer the other, then rotation of the bundle will ensue, since the portion under the screen, which is cooler and therefore magnetizable, is continually more strongly attracted than the other and heated portion. This device acts therefore as a pyromagnetic motor, the heat now passing through the tubes in such a way as to produce a dis-symmetry in the lines of force of the iron-field, the rotation being due to the effort to make these symmetrical. The guard plate in this case has an action analogous to that of the commutator in an ordinary armature. The first experimental motor constructed on this principle was heated by means of two small Bunsen burners, arranged with an air blast and it developed about 700 foot pounds per minute. A second and larger motor is now about finished, which will weigh nearly 1,500

[1] I am aware that motors embodying the same principles have been described by Houston and Thomson (*J. Frank. Inst.*, 1879, 89,) by McGee (*Science*, III, 274, 1884) and by Schwedoff (*J. Physique*, II, v. 362, 1886). But it does not appear that the apparatus described in these publications was ever actually constructed; except in the case of McGee's model, which was scarcely more than a toy. Indeed in both of the papers first above mentioned, the motor is stated to be of theoretic interest only and to have no practical value.

pounds and is expected to develop about three horse power. In both these machines, electromagnets are used in place of permanent magnets, the current to energize them being derived from an external source. In the latter machine, the air for the combustion is first forced through the tubes to aid in cooling them and then goes into the furnace at a high temperature.

The earliest experiments in the direction of the pyromagnetic production of electricity were made with a very simple apparatus, consisting of a charged electromagnet, having a tube of thin iron passing through its cores near their outer ends, a coil of wire being wound round this tube, and including an ordinary sounder delicately adjusted, in its circuit. The tube beneath the coil was covered with asbestos paper. After heating the tube to redness by a gas blast directed into it at one end, a jet of cold air was suddenly substituted for the flame; the sounder at once closed showing that the change in the magnetizability of the iron had varied the distribution of the lines of force within the coil, and thus had produced a current of electricity in this closed circuit.

The construction of a machine of sufficient size to demonstrate the feasibility of producing continuous currents on the large scale in this way was at once begun and has only just been completed. The new machine consists of eight distinct elements each the equivalent of the device already mentioned, consisting of the two legs of an electromagnet somewhat far apart (twelve inches actually) having at one end the ordinary yoke and at the other a roll of corrugated sheet iron .005 inch thick, called an interstitial armature; this armature having a coil of wire wound upon it and separated from direct contact by means of asbestos paper. The eight elements are arranged radially about a common centre, and are equidistant, the eight interstitial armatures passing in fact through two iron disks, which constitute the common pole pieces of all the electromagnets. The coils wound upon the interstitial armatures are connected directly in series, the whole forming a closed circuit. Through the centre of these disks a hollow vertical shaft passes, carrying at its lower end a semicircular plate of fire clay called a guard plate which, when the shaft is turned, revolves close to the lower ends of the sheet iron armatures and screens off half of them from the access of heat from below. The shaft carries a cylinder of insulating material having metallic contact pieces let into it on opposite sides, the line joining them being parallel to the straight edge of the guard plate. Upon this cylinder eight springs press, each of these springs being connected to the wire of the closed circuit above mentioned midway between the coils. The length of the metallic segment is so proportioned that the following spring touches it just as the preceding one leaves it. The springs themselves are so adjusted that each of them comes into contact with its metallic segment just as the preceding coil of the pair, to which it is connected, is uncovered by the rotation of the guard plate. Upon the same shaft and above the cylinder just mentioned, a pair of metallic rings are placed, insulated from the shaft, to each of which one

of the metallic segments is connected. Brushes pressing upon these rings take off the current produced by the generator.

The entire machine now described is placed upon the top of any suitable furnace, fed by a blast, so that the products of combustion are forced up through those interstitial armatures which are not covered by the guard plate, and raise them to a high temperature. The field magnets when charged magnetize of course only those interstitial armatures which are cold; *i. e.*, those beneath the guard plate. On rotating this plate, the interstitial armatures are successively uncovered on the one side and covered on the other; so that continually during the motion four of the eight armatures are losing heat and the other four are gaining heat. But those which are losing heat are gaining magnetism, and *vice versa*. Hence while currents are generated in all the armature coils, since in all the magnetism is varying, the current in the coils beneath the guard plate will be in one direction, while that in the coils exposed to the fire will be in the other. Moreover, whenever an armature passes ont from under the guard plate, its condition at once changes: from losing heat and gaining magnetism it begins to gain heat and lose magnetism. Hence at this instant the current in its coil is reversed; and consequently the line connecting this coil with the one opposite to it constitutes the neutral line or line of commutation; precisely as in the ordinary dynamo. Indeed, the action of the interstitial armature coils of the pyromagnetic dynamo resembles strongly that of the ordinary armature coils of the Gramme ring, not only in the manner of connecting them together but also in their functions; the change of direction in the current as the magnetism of the field changes sign in the latter case corresponding closely to the change of current in the former case due to the direction of the temperature change. But it will be observed that while in the Gramme ring, the loops between the armature coils are connected to commutator segments equal in number to that of the coils, upon which commutator two brushes press, in the pyromagnetic dynamo the loops between the armature coils are connected to an equal number of brushes (in this case eight), while the commutator segments are only two in number. So that the functions of the commutator and the brushes in this generator are in a certain sense reversed as compared with the ordinary dynamo.

The potential difference developed by this dynamo will obviously depend (1) upon the number of turns of wire on the armature coils; (2) upon the temperature difference in working; (3) upon the rate of temperature variation and (4) upon the proximity of the maximum point of effect. No advantage will be gained of course by raising the temperature of the interstitial armature above the point at which its magnetizability is practically zero; nor will it be advantageous on the other hand to cool it below the point where its magnetism is practically a maximum. The points of temperature therefore between which for any given magnetic metal, it is most desirable to work, can be easily determined by an inspection of the curve showing the relations between heat and magnetism for this particular metal. Thus the points of temperature at which the magnetizability is

practically zero, as above stated, are a white heat for cobalt, a bright red for iron and 400° for nickel. On the other hand while at ordinary temperatures iron has a maximum intensity of magnetization represented by 1390, its intensity at 220° is 1360; and hence no commercial advantage is gained by cooling the iron below this temperature. Nickel, however, whose maximum intensity of magnetization at ordinary temperatures is 800, has an intensity of only 380 at 220°. Hence while this metal requires a lower maximum temperature it also requires a lower minimum one; but it may be worked with much less heat. The rate of the temperature variation is determined by the rapidity which the guard plate revolves. And this in its turn is dependent upon the rapidity with which the interstitial armature can be cooled and heated. That it may take up and lose heat readily, the sheet iron of which it is made is very thin (only .005 inch thick even when its durability is increased by enameling or nickeling), it is corrugated and rolled up so as to expose a large surface (about 60 sq. ft. for the eight armatures) and hot and cold air are alternately forced through the armature. Experiments already made show that the guard plate can probably be made to revolve one hundred and twenty times a minute. Since the potential difference is proportional to the number of lines of force cut per second, it is evident that by doubling the speed of rotation, twice as many lines of force would flow across the generating coils per second and the output of energy would be quadrupled. Exactly what thickness of metal is the most suitable for the purpose, what the relative volume occupied by metal and by air space in the interstitial armature should be, what is the best diameter for this armature, or even the best metal, what the best limits of temperature and what the best speed of rotation to produce the maximum potential difference — all these are questions which must be decided by experiments made upon the generator itself.

The results thus far obtained lead to the conclusion that the economy of production of electric energy from fuel by the pyromagnetic dynamo will be at least equal to and probably greater than that of any of the methods in present use. But the actual output of the dynamo will be less than that of an ordinary dynamo of the same weight. To furnish thirty sixteen-candle lights in a dwelling house would probably require a pyromagnetic generator weighing two or three tons. Since, however, the new dynamo will not interfere with using the excess of energy of the coal for warming the house itself, and since there is no attendance required to keep it running there would seem to be already a large field of usefulness for it. Moreover by using the regenerative principle in connection with it, great improvement may be made in its capacity, and its practical utility may very probably equal the interesting scientific principles which it embodies.

A CLASSIFICATION OF THE WINDS. By WILLIAM M. DAVIS, Cambridge, Mass.

DESCRIPTION OF A COMBINED CHRONOGRAPH AND WEIGHT MOTOR. By Prof. WM. A. ROGERS, Waterville, Me.

TIME OF EXPLOSIVE AND MASS CONSIDERED AS FUNCTIONS OF THE RATE OF SATURATION OF HEAT IN THE CASE OF MERCURY AND WATER. By Prof. WM. A. ROGERS, Waterville, Me.

ON THE DEFINITION OF THE OHM BY THE EQUATION $R = K \frac{e}{s}$. By Prof. WM. A. ROGERS, Waterville, Me.

A METHOD OF OBTAINING THE CONSTANT OF GRAVITY FROM THE COMPARISON OF MUSICAL NOTES. By Prof. WM. A. ROGERS, Waterville, Me.

NOTATION FOR PHYSICAL UNITS. By Prof. A. MACFARLANE, University of Texas, Austin, Texas.

COLOR BLINDNESS OF RAILWAY EMPLOYÉS. By Dr. WILLIAM THOMSON, Philadelphia, Pa. [This paper will be found in full in the Medical News, and in Popular Science Monthly for October, 1887.]

ON A RELATION BETWEEN THE QUANTITIES OF HEAT COMBINATION IN AQUEOUS SOLUTION. By Prof. C. F. DE LANDERO, Guadalajara, Mexico.

THE ELECTRIC CURRENT AS A MEANS OF INCREASING THE TRACTIVE ADHESION OF RAILWAY MOTORS AND OTHER ROLLING CONTACTS. By ELIAS E. RIES, Baltimore, Md.

A PECULIAR FORM OF UNDULATORY CURRENT UNITED TO TELEGRAPHING OR TELEPHONE CIRCUITS. By Dr. P. H. VAN DER WEYDE, Brooklyn, N. Y.

GRAVITATION ETHER. By Prof. DE VOLSON WOOD, Hoboken, N. J.

SECOND LAW OF THERMODYNAMICS. By Prof. DE VOLSON WOOD, Hoboken, N. J.

A METHOD OF EXAMINING MAGNETIC DOUBLE CIRCULAR REFRACTION. By DE WITT B. BRACE, Lockport, N. Y.

ON THE TRANSPARENCY OF THE ETHER AND ITS POSSIBLE VISCOSITY. By DE WITT B. BRACE, Lockport, N. Y.

THE MUTUAL ACTION OF THE ELEMENTS OF AN ELECTRIC CURRENT. By E. B. ELLIOTT, Washington, D. C.

EXPERIMENTAL DETERMINATION OF THE REACTION OF A LIQUID JET. By Prof. J. BURKITT WEBB, Stevens Institute of Technology, Hoboken, N. J.

A NEW VISCOSIMETER. By Prof. J. BURKITT WEBB, Stevens Institute of Technology, Hoboken, N. J.

NOTES ON STANDARD CELLS. By Prof. H. S. CARHART, Ann Arbor, Mich.

IS TERRESTRIAL MAGNETISM CONCERNED IN ATMOSPHERIC MOVEMENTS? By W. A. VEEDER, Lyons, N. Y.

INFLUENCE OF TOPOGRAPHY UPON RAINFALL. From observations during the year 1884, at Houghton Farm, Mountainville, Orange Co., N. Y. Read by Prof. HENRY E. ALVORD, Amherst, Mass.

THE SIGNAL SERVICE BIBLIOGRAPHY OF METEOROLOGY. By Prof. CLEVELAND ABBE, U. S. Signal Service Office, Washington, D. C.

ON THE RELATIVE VELOCITY OF THE EARTH AND THE LUMINIFEROUS ETHER. By ALBERT A. MICHELSON, Master U. S. Navy, and Prof. EDW. W. MORLEY, Cleveland, Ohio.

ON A METHOD FOR MAKING THE WAVE LENGTH OF SODIUM THE ACTUAL AND PRACTICAL STANDARD OF LENGTH. By ALBERT A. MICHELSON, Master U. S. Navy, and Prof. EDW. W. MORLEY, Cleveland, Ohio.

THE DIFFICULTY OF DETERMINING THE DIRECTION OF THE SOURCE OF SOUND OF FOG-SIGNALS AT SEA. By A. B. JOHNSON, Light House Board, Washington, D. C. [This paper will be printed in full in Popular Science Monthly.]

SECTION C.

CHEMISTRY.

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ADDRESS

BY

PROFESSOR ALBERT B. PRESCOTT,

VICE PRESIDENT, SECTION C.

THE CHEMISTRY OF NITROGEN AS DISCLOSED IN THE CONSTITUTION OF THE ALKALOIDS.

To the compounds of carbon, chemistry has devoted its main strength, ever since this science reached maturity of purpose. In the work among organic compounds science has made its nearest approaches to an actual acquaintance with the molecule as a chemical centre, and from these advances every branch of chemical art receives full benefit.

Carbon was the first to gain attention as the member giving specific character to organic compounds (1)[1]. Hydrogen entered into the definition of organic chemistry (2) at a later period. At present, hydrocarbons are represented to be the parent forms of chemical families, with carbon as the member for fixed position and hydrogen as the member for exchange. Upon these two elements, and upon their relations in the molecule, investigation has fixed its steadfast eyes in the will to divine the ways of chemical action.

Nitrogen comes next in turn as an organic element of importance. Hitherto, for the most part, organic nitrogen has been regarded only as a member peculiar to certain categories of carbon compounds. The name of nitrogen has not entered into any definition of general or commanding interest. Nevertheless, *the carbonaceous compounds of nitrogen* have already so appeared as to shed a good light upon chemical structure. It is hardly too much to say that in the study of these compounds lies before us the very organic chemistry of organic chemistry.

Through the inorganic world and its majestic round of supplies

[1]List of references at end of the address.

for the sustenance of living bodies, nitrogen has been noted as a unique element. The physiological availability of the free nitrogen of the air, long found a divided question, was well discussed in the last annual address before this section. The artificial conversion of atmospheric nitrogen into ammonia, an old attempt, is constantly urged at the hands of invention by new demands from the great chemical industries. The service of nitrogen in the explosives, fairly well under control in the use of projectile agents, is still in the need of improvements for safety and for rate of action. The element assumes strangely diverse relations: it presents to us an enigma in physiology; it leads in our estimates of the agricultural value of plant foods; it stands in its indifference as an obstruction in the way of great chemical manufactures; it keeps the post of a trusted agent for projectile force in arts of war and of peace; it mocks us with its abundant presence in an inapproachable virgin state: the same element that holds the structure of the aniline dyes and governs the constitution of the vegetable alkaloids. The character of nitrogen challenges chemical skill.

The chemistry of nature instructs the chemistry of art. Molecular syntheses wrought out in the vegetable kingdom, sometimes too complex for analysis, often too difficult to reproduce, always claim our study; and the reasons so far shadowed forth are more than enough to justify the attempt here entered upon to trace back the path of attainment, and take the bearings of our progress in the chemistry of nitrogen as disclosed in the structure of the alkaloids.

The history and the present state of the constitution of the vegetable alkaloids, and other nitrogenous bases, may be outlined in the following order:

(1) The conception of the type of ammonia in the formation of nitrogenous bases. The light of this theory has enabled great numbers of artificial compounds to be produced, but for the most part it has failed to reveal the structure of the vegetable alkaloids.

(2) The study of the aromatic type of structure in closed chains of six positions of carbon, conjoined with the ammonia type in side chains. Great numbers of new bases of amido-benzenoid constitution have been produced while the benzenoid type has been found in but few of the vegetable alkaloids.

(3) The demonstration of the pyridine and quinoline aromatic groups, holding nitrogen in position within the closed chain in

the constitution of numerous vegetable alkaloids. Already artificial production of both new and natural alkaloids follows up the discovery of the pyridine type of formation.

(4) The researches upon azo and diazo-benzenoid bases, in which nitrogen is linked to nitrogen in an open side chain of benzenoid molecules. Color substances in abundance have been made upon these types, and a late announcement implies that the diazo structure takes part among animal decomposition products.

I. Nitrogenous Bases as Derivatives of Ammonia.

It was remarked by Justus Liebig in 1830 (3), that the capacity for saturation of acids, possessed by the plant bases, was in proportion to the number of equivalents of nitrogen they contained. As early as 1837 Berzelius (4), reasoning on the results of Regnault and Liebig, advanced the doctrine that the vegetable bases were conjugated compounds of ammonia,— binary combinations in which the entire molecule of ammonia was united with a group or compound radical containing carbon — represented by $H_3 N X$. The saturating power of the alkaloid was stated to be the same as that of the contained ammonia. Liebig departed from the doctrine of Berzelius to this extent, that he held the organic bases to be binary combinations, not of entire ammonia, but of amidogen, so that they were represented by $H_2 N Y$. Liebig's view looked toward but did not reach the idea of substitution for the hydrogen in ammonia.[2] The doctrine of Berzelius as a whole, " by no means met with general approbation, but" to use the words of Hofmann, " it was retained and carried out by Berzelius with the perseverance and ratiocination peculiar to that great chemist."

At the time of these studies, vegetable alkaloids had been known in the chemical world for about twenty years. The chief bases of opium, cinchona, strychnos, veratrum, aconite, and the solanaceous plants had been obtained. The first distinct announcement of a plant base was that of morphine by Sertürner in 1805, but this did not gain attention until Sertürner's fuller report in 1817 (5). In 1803, however, Derosne (6) had obtained a " crystallizable

[2] In 1840 (*loc. cit.*) he made a remarkable prediction of the nature of the amines, obtained by Wurtz and by Hofmann ten years afterward. " If," said Liebig, " we were able to replace by amidogen the oxides of methyl and ethyl, and of two basal radicals, we should without the slightest doubt obtain a series of compounds exhibiting a deportment similar in every respect to that of ammonia. Thus a compound of the formula C_2H_5 H_2N would be endowed with the properties of a base."

opium salt" by two methods, one of which must have given him morphine, and the other, narcotine. In 1844, about fifty vegetable alkaloids were enumerated, including some whose identity has not been established (7).

The disadvantage incurred in investigation of organic bases under the Binary Theories of Berzelius and Liebig is shown by the difficulty described by A. W. Hofmann (8) in London, as late as 1849. "Vainly have I hoped in the course of my investigation on this subject," he says in conclusion of a paper on certain organic compounds of ammonia, "to cause aniline to split up into ammonia and the conjunct C_6H_4."[3] The introduction of the Theory of Substitution and the Theory of Types by Dumas and Laurent (9) prepared the way soon after 1840 for the production of derivatives from ammonia.

The first representatives, methylamine and ethylamine, were obtained by Adolph C. Wurtz, in February, 1849 (10) — through the action of potash upon the cyanic ethers.[4] The year before he had made report (11) on the same reaction, with the surmise that he had obtained a derivative either of a urea or of an ether,[5] but after obtaining methylamine as a caustic volatile alkali, he was emphatic in declaring it an ammonia. "I have succeeded, in fact," he said, "in converting ammonia into a true organic compound, by adding to it the elements of the hydrocarbon $C\,H_2$."[6] Wurtz at first christened the new products "methylamid" and "ethylamid." Mr. T. Sterry Hunt, then writing in Silliman's Journal (12), proposed the names of "methylamine," "ethylamine," etc., as "more consonant with the nomenclature of the alkaloids." The names "methyliak," "butyriak," etc., were offered by Dumas; and the names "methammine," "ethammine," etc., by Gerhardt (13). In his communication of August, 1849, Wurtz adopts the terms "methylamine," etc., and about this time he presents rational

[3] Original, $C_{12}\,H_4$.

[4] That is, the methyl and ethyl isocyanates. Also by action of potash on the isocyanurates, and ureas.

[5] "Either a urea in which one equivalent of water is replaced by one of ether, or methyl ether in which the molecule of oxygen (weight 8) is replaced by a molecule of amidogen, $N\,H_2$." The latter view corresponds to that in the prediction of Liebig already quoted.

[6] "Ammonia," said Wurtz, "should decidedly be regarded as the most simple and most powerful of the organic bases; and it would be for all chemists the type of that numerous class of bodies, did it not differ in one undoubtedly important character, but to which," he concludes, "an exaggerated value has been attributed. Ammonia contains no carbon."

formulæ, on the ammonia type, for a good number of artificial bases, aniline, toluidine, and picoline, for nicotine, and conine, and claims formulæ for several oxygenated bases.

Dr. Hofmann had been engaged in investigation "on the volatile organic bases," communicated in 1849 and 1850 and already referred to (8), and he welcomed "the splendid investigation of M. Wurtz" with unstinted enthusiasm. He now adopted the theory of substitution for the hydrogen of ammonia, and with remarkable celerity he verified the theory by replacing the second and the third atoms of hydrogen by organic radicals. Beyond this he substituted the fourth hydrogen atom of ammonium salts, explained the formation of "white precipitate" and other metallic derivatives, and set forth the likeness of oxygenated alkaloids to the compounds of ammonium. For the greater number of his results he employed the simple reaction which bears his name, the reaction between iodides or bromides of radicals and the ammonia or lower derivatives of ammonia. His masterly reports of 1850 and 1851 fill seventy-eight pages of the Philosophical Transactions (14), concluding with an extensive classification of new substances, and with ambitious expectations of finding the constitution of important vegetable bases. This reaction, used by Hofmann for the introduction of "alkyls" or alcohol radicals into ammonia, producing successively primary, secondary and tertiary amines and then alkyl ammonium salts, is a reaction now in constant use upon alkaloids in the course of investigations. By this reaction, for example, morphine is convertible into methyl-morphine, which is codeine, and an homologous ethyl-morphine is readily obtained (15). Brucine is dimethoxy-strychnine; a methyl-strychnine and an ethyl-strychnine are produced (16); and these artificial products are under trial as to their physiological effects. Quinine is a methoxy-cinchonine. Cocaine is readily formed by the introduction of methyl into benzoyl-ecgonine, and the corresponding ethyl, propyl, and butyl products are now under physiological trial (17). It is of great practical interest that homologous alkaloids, prepared by successive substitutions of methyl through Hofmann's reaction, are found to exhibit a gradation of physiological intensity quite in correspondence with the graded intensity of the homologous alcohols of the paraffin series.

Whatever we have gained by modern theories of other types of structure it still remains true that the nitrogenous bases represent the type ammonia. Whatever other types govern the constitution

of alkaloids in general, they carry central atoms of nitrogen, whose valence and whose chemical activities are typified by the nitrogen of this simple volatile alkali. Nevertheless, the type ammonia represents only the "ammonia-rest," a small part of the molecule of a natural fixed alkaloid. Unable to reach a clew to the constitution of the larger part, and therefore without data as to the relations and valences held by nitrogen, chemists were not able to assign rational formulæ to the oxygenated alkaloids of plants in general until within the past ten or fifteen years, during which time light has been obtained upon typical structures of the carbon and hydrogen of these bases.

II. Nitrogenous Bases represented by Aniline.

Phenylamine or amidobenzene is the type, in its simplest form, of compounds made by the substitution of an aromatic radical in ammonia. Obtained by distillation from indigo in 1826, from coal-tar in 1834, and from benzene by reduction of the nitro-derivative in 1841, it was at once recognized by Wurtz and by Hofmann, in 1850, as a primary amine. Its aromatic constitution, with that of benzene itself, came to light in the closed chain theory of Kekulé in 1865 (18). The aniline color industry, instituted by the inventions of Perkin in 1856, could not have reached its great and beneficent development without the impulses due to the knowledge, first, of the ammonia type in the linking of nitrogen, and second, of the closed chain of six positions of carbon.[7] On the other hand, the resources of pure organic chemistry could not have reached the wide extent they have attained without the patient and efficient investigation of the industrial chemists engaged in the work of the world.

While the aromatic type of structure has furnished artificial nitrogenous bases for innumerable dye-stuffs, the inquiry whether any considerable number of the alkaloids of plants were aromatic compounds or not was for years a perplexing question. Large numbers of vegetable alkaloids yield simple aromatic products when decomposed. For example, atropine and its related alkaloids, when heated or forcibly oxidized, yield benzoic and salicylic aldehydes and related bodies. At the same time, research has failed to find rational formulæ for alkaloids wherein nitrogen was attached, as it is in aniline, to a benzenoid group—a closed chain

[7] In use of the chemical term position the author will be understood to refer, not to arrangement in space, but to the order of union of atoms with each other.

of six carbon positions. It was not until the discovery of the pyridine and quinoline type in the alkaloids — a type of aromatic structure holding five positions of carbon and one of nitrogen within the closed chain—nitrogen in a position central to the molecule—that it could be understood in what way the natural alkaloids, yielding aromatic decomposition products, were themselves of aromatic composition.

Before taking up the consideration of the pyridine type of bases, it may be said that the complete benzenoid group, so extensively found in vegetable acids, has been very little found in vegetable bases. In narcotine and narceine, the benzenoid group is found with four hydrogen atoms replaced, but not at all replaced by nitrogen. The nitrogen of the compound is not directly linked to the complete benzenoid group.

III. The Pyridine Type in the Vegetable Alkaloids.

The aromatic constitution of pyridine and quinoline was apprehended in 1870 (19). In this constitution, pyridine differs from benzene only in the substitution of one trivalent N, for the trivalent group CH; and quinoline differs from naphthalene only in the substitution, in the same way, of one N for one CH. As constituted in closed chains of six positions, pyridine and quinoline are aromatic compounds, but of a type radically different from that of complete benzenoid bodies conjugated with nitrogen, like aniline or azo-benzene. The pyridine molecule, C_5H_5N, violates the first condition of benzenoid compounds, namely, that the six primary positions of the molecule, C_6H_6, are all equal to each other. Here we have *nitrogen interlinked in the closed chain* in the position of central influence. The great numbers of compounds which have been found in nature and formed by art, upon the pyridine type, during the last sixteen years, give evidence that this type is an essential effect of *the chemism of nitrogen* as much as the benzene type is an effect of the chemism of carbon. The fact that only one atom of nitrogen is found to enter the closed chain of six positions renders it not unlikely that the nitrogen atom is directly united to more than two atoms of carbon in the ring. That the nitrogen is united to three atoms, Riedel and others (20) sometime since concluded on experimental grounds.

That the vegetable alkaloids containing oxygen are *tertiary* amines, or ammonium compounds, so that they do not contain hy-

drogen directly united to their nitrogen—and so that all the hydrogen of the typical ammonia is replaced—was announced by Hofmann, in 1851, and has always been assented to. With this view, the theory of the pyridine type quite accords. Pyridine and quinoline are actually tertiary amines, and their derivatives retain the exclusion of hydrogen from the first three valences of nitrogen, those which represent hydrogen of ammonia.

In their isomerisms and in their deportment, pyridine and quinoline resemble benzene and naphthalene, their simpler aromatic types. By the facility of substitution of methyl and other radicals for their hydrogen, they yield homologous series; by oxidation of the alcohol radicals, carboxylic acids are obtained; and by reduction of the acids, the original compounds are restored. In a very important quality, however, pyridine differs from benzene in deportment, that the former gives much more stable addition products with hydrogen than can be obtained from the latter. Two, four, or six atoms of hydrogen are united. Hexahydro-pyridine is the alkaloid piperidine. Piperidine in union with piperic acid constitutes the piperine of black pepper, the latter being, therefore, a saponifiable alkaloid. The pyridine from which is derived tropine, the central group in solanaceous alkaloids, is tetrahydrated, and the typical quinoline in the cinchona alkaloids is tetrahydrated. The stability of these addition products renders possible the great complexity of natural derivatives of pyridine. And in this capacity for larger combinations we have proof, again, that *the chemism of nitrogen* introduces distinct character into the pyridine derivatives.

Pyridine was obtained from bone-oil in 1850 (21), from coal-tar in 1855 (22), by synthesis from an azo compound in 1865 (23), and may be prepared from various alkaloids by distilling them with alkali. A pungent liquid, miscible with water, boiling at 116.7°C., its appearance scarcely commends its claim to be the chemical protoplasm of the alkaloids of plants. Quinoline was obtained from quinine and from strychnine in distilling with alkali by Gerhardt, in 1842 (24), from the latter distillates of coal-tar as finally confirmed by Hoogewerff in 1883, from bone-oil, along with pyridine, and by synthesis in several ways, best from nitro-benzene with aniline and glycerine as done by Skraup in 1881. As a liquid it corresponds in appearance as it does in composition to pyridine, being heavier and less volatile. It is easily oxidized to pyr-

idine dicarbonic acid, as naphthalene is to phthalic acid,—as by the cutting away of one of a pair of joined hexagons. When manufactured from cinchonine quinoline it is accompanied by lepidine[8], as prepared from nitrobenzene it is liable to retain the latter as an impurity. It is in demand for color-manufacture and for introduction to medicinal uses. Pyridine is still prepared from bone-oil, but should much demand arise for it, more favorable sources would doubtless be found.

About eight years ago the researches of many chemists reached the discovery of the pyridine type of constitution in several groups of the vegetable alkaloids. In some instances, as in the chief cinchona alkaloids, results have established a rational aromatic formula for the entire base as it exists in nature. In other instances, the pyridine type has been revealed, not at first in the natural alkaloid as a whole, but in an alkaloid previously found to lie within the alkaloid of nature, and obtained therefrom by reactions fairly denoted as those of saponification. And before bringing up examples of the pyridine and quinoline types of constitution, it is necessary to summarize the principal saponifiable alkaloids with the products into which they split up.

The saponification of alkaloids, as accomplished in the last thirty years, corresponds, in its delightful simplification of complex compounds, to the saponification of fats achieved over fifty years ago,—with this striking difference, that the chief or representative product of the saponification of an alkaloid is another alkaloid while the more elaborate product of the saponification of a fat is usually an acid. Indeed, in case of an alkaloid, its saponification may be defined as the removal of an acid or other radical, by replacing it with hydrogen. And the saponification of alkaloids does not fulfil the accepted definition of chemical saponification, in that its resulting base in most cases does not appear in classification as an alcohol, nor is the subject of the decomposition classed as an ester. The saponification of alkaloids is instituted by action of an alkali then left in union with the resulting acid, or by an acid then left in union with the obtained new alkaloid, or by digestion with only water, which of course is always taken up. The following are representative instances of the saponifications of alkaloids:

[8]For the manufacture of cyanine, the lepidine is necessary, pure quinoline not yielding this blue coloring matter in treatment with amyl iodide and alkalies (HOOGEWERFF and VAN DORP, 1882).

Atropine with *water* yields *tropine* and *tropic acid* (25).
$C_{17}H_{23}NO_3 + H_2O = C_8H_{15}NO + C_9H_{10}O_3$

Aconitine with *water* yields *aconine* and *benzoic acid* (26).
$C_{33}H_{43}NO_{12} + H_2O = C_{26}H_{39}NO_{11} + C_7H_6O_2$

Cocaine with *water* yields *benzoyl-ecgonine* and *methyl alcohol*
$C_{17}H_{21}NO_4 + H_2O = C_{16}H_{19}NO_4 + CH_4O$ (27).

Benzoyl-ecgonine with *water* yields *ecgonine* and *benzoic acid.*
$C_{16}H_{19}NO_4 + H_2O = C_9H_{15}NO_3 + C_7H_6O_2$

Narcotine with *water* yields *hydrocotarnine* and *meconine* (28).
$C_{22}H_{23}NO_7 + H_2O = C_{12}H_{15}NO_3 + C_{10}H_{10}O_5$

Cevadine with *water* yields *cevine* and *methylcrotonic acid* (29).
$C_{32}H_{49}NO_9 + H_2O = C_{27}H_{43}NO_8 + C_5H_8O_2$

Veratrine with *water* yields *verine* and *veratric acid.* (29)
$C_{37}H\ NO_{11} + H_2O = C_{28}H_{45}NO_8 + C_9H_{10}O_4$

Piperine with *water* yields *piperidine* and *piperic acid* (30).
$C_{17}H_{19}NO_3 + H_2O = C_5H_{11}N_9 + C_{12}H_{10}O_4$

Each reaction of saponification here cited is limited to the single step taken in the appropriation of one molecule of water.[9] In the case of cocaine, a second saponification directly follows the first, and treatment may yield together the products of both reactions.

After Chevreul effected the saponification of ordinary fats, it was a long time before the reverse change was obtained in the synthesis of fats from fatty acids and glycerine. But not so long an interval interposed between the analytic and the synthetic results represented by the saponification of some of the alkaloids. The construction of atropine by union of its saponification products was brought about by Ladenburg in 1879 (31). The like synthesis of cocaine was obtained by Skraup, and by W. Merck, in 1885 (32).

The liability of alkaloids to saponification is a property that closely concerns the treatment they receive in manufacture and in pharmacy, and gives explanation of numerous perplexities in practical operations. These very perplexities have sometimes been assumed to show that results promised by theory fail to appear in practice, — a failure that finds remedy in this case as in many others, by a more liberal use of just the theoretical knowledge

[9] According to Wright, japaconitine, with three molecules of water, yields two molecules each of japaconine and benzoic acid.

complained of. At all events, the operations of pharmacy have been the source of unnumbered contributions to the pure chemistry of the alkaloids, and this indebtedness of science pays honor to faithful investigations, represented in a rich and extensive body of pharmaceutical literature.

Returning to our inquiry into the discovery of the pyridine type of aromatic composition in the alkaloids, we find the last three years to have been a period of great attainment. It may be placed first that tropine, the common base of the entire atropine group of alkaloids, the midriatic alkaloids of the solanaceæ, is itself a derivative of pyridine. This was experimentally established in 1884 and 1885, by Ladenburg (33), Hofmann, Hantzsch, and Königs. In 1882 Ladenburg had termed tropine "a nitrogenous alcohol of which the tropines are the ethereal derivatives." But after a succession of reports on the nature of tropine, beginning in 1881, Ladenburg has presented evidence, fully confirmed by others just named, that tropine is directly derived from pyridine. Starting with tetrahydro-pyridine, the introduction of an ethylene-hydroxyl and a methyl, in place of two atoms of hydrogen, forms tropine: $C_5H_7\ (C_2H_4OH)\ N\ (CH_3)$.

Piperidine, the decomposition product of the alkaloid of black pepper, was shown by Hofmann, in 1879 (34), and by Ladenburg and Roth in 1884, to be a hexahydro-pyridine. Nicotine, the volatile alkaloid of tobacco, is a dihydro-dipyridine, as claimed in 1880 by Wischnegradsky (35). Conine, early classed as a secondary amine, is ascertained to be a propyl-piperidine (36).

The alkaloids of cinchona barks, though counting over twenty-five in number, are certainly represented in their constitution by cinchonine, of which quinine is the oxymethyl derivative.

In 1881, Wischnegradsky deduced from his results that cinchonine contains both a quinoline and a pyridine group, but accumulating proofs since render it strongly probable, if not certain, that cinchonine is a quite simple di-quinoline derivative (37). Starting with quinoline, then tetrahydrated, two molecules unite by dropping a hydrogen from each, when oxymethyl is made to replace one hydrogen for cinchonine, or two hydrogens for quinine.[10]

This is by no means an account of the pyridine type as known

[10] $C_9H_{10}N.C_9H_9N.(O.CH_3)$, cinchonine.
$C_9H_{10}N.C_9H_8N.(O.CH_3)_2$, quinine.

in all the alkaloids. Strychnine and brucine are the subjects of especial activity, and it is clear that they are pyridine compounds, as are also the alkaloids of opium.

The evidence seems to be, at present, very strong, that, in general terms, the vegetable alkaloids are hydrogenized pyridine derivatives. Under the belief that any useful understanding of the structure of these bodies must be based upon a full experimental acquaintance with the pyridine and quinoline series, there is great activity in the study of the typical compounds. For some time, now, researches have been undertaken to find the positions of groups introduced into these bodies (38). On the success of these studies of chemical position, the chemistry of the natural alkaloids will in the future necessarily depend. Until the isomerisms due to position are under control, there can be no distinction established between, for example, numbers of compounds, each having the same constituent groups represented in the present formula for quinine, or in that for atropine. Also the present acquaintance with plant bases, accumulated in the progress of analytical chemistry, has still to be advanced, as a foundation for studies of chemical structure.

General methods of synthesis of pyridine derivatives have been sought at many hands. The reaction of Hofmann, beginning with alkyl iodide addition products, on subsequent exposure to a high temperature in sealed tubes, results in the substitution of radicals in pyridine compounds. The production of the hydrogen addition compounds, as piperidine, is effected only by the strongest of reducing agents, such as metallic sodium applied in alcoholic solution (39). This affords another illustration, that the most violent reducing agencies of the laboratory are required to accomplish changes constantly carried on by the silent forces of plants.

At the present time, there appears a degree of encouragement, that the synthetic manufacture of the alkaloids, hitherto obtained from plants, will sometime become realized as an industry. Not from the chance efforts of ignorant dreamers, nor from any premature short cuts of special attempt, but, if at all, from the well-earned progress of the science of the world will these results be accomplished.

A large amount of well directed chemical investigation in the service of manufacturing interests is devoted to reasonable questions of new production of alkaloids— including the conversion of

those more abundant into those more valuable. Artificial alkaloids of a composition allied to natural ones are being constantly put upon trial as respects their usefulness in medicine and the arts. The periodicals of pharmacy and medicine are thickly strewn with records of the physiological power of new alkaloids, especially of quinoline derivatives of many forms, "Kairines E. to Q.," "thallines," and "antipyrines," ethyl morphine, and methyl and ethyl strychnine. It should not surprise us, if, at any time, artificial alkaloids should assume a commercial importance rivalling that of articles already brought into general use, such as carbolic and salicylic acids.

IV. New Azo and Diazo Bases.

It was said that the nitrogen of organic bases in general, whether of the pyridine type or otherwise, still conforms to the type of ammonia, preserving the valence and the character so well known in ammoniacal compounds. To this statement perhaps an exception should be made, as it does not apply to the diazo compounds. However, the diazo compounds are not distinctly bases, but act both as bases and as acids. The azo compounds, acting alone, are scarcely bases at all, but in conjugation as azo-amido compounds they unite with acids to form salts, and such salts owe much of their character to their azo-nitrogen. The nitrogen of the class of azo and diazo compounds in general is nitrogen acting in a way intermediate between that of the basal nitrogen of the ammonia type and acidulous nitrogen of organic nitro-acids. And so far as they represent bases, the diazo and azo types of structure must be taken into account in a survey of the base-forming activities of nitrogen.

The diazo compounds were produced (40) shortly before the date of Kekulé's lucid theory of aromatic chemistry; the azo compounds were obtained (41) much earlier, but both classes of substances were seen through definite rational formulæ after 1865 (42). The diazo group contains two atoms of nitrogen so interlinked that the group serves, with a valence of only two, to connect the benzene group on one side with an acid or metallic radical on the other side. Diazo compounds are very frail, readily breaking up with explosive violence, due to the liberation of free nitrogen. The azo compounds, less instable, have the same bivalent group of two ni-

trogen atoms, here interposed between two benzene rings. Whatever be the truth as to the valences of nitrogen in the diazo group it is impossible to avoid thinking that the two atoms are united to each other by two units of valence of each: (— N=N —). This structure, at all events, is wholly unlike that of the ammonia type, but bears some resemblance to that of isocyanogen.

Almost innumerable color compounds of the azo and diazo formation have been manufactured from coal-tar materials, but not until now (to the writer's knowledge) has the azo type been discovered in immediate relation to natural organic products.

This year Dr. V. C. Vaughn, from further work upon the albuminoid decomposition product tyrotoxicon (43), has announced the identity of this body with diazobenzene (44), and says, "We think it highly probable that diazobenzene or some closely allied substance will be found in all those foods, which from putrefactive changes produce nausea, etc." The same author gives his conviction that diazobenzene, and possibly allied bodies, are "transition products of putrefaction."

The study of albuminoid constitution has scarcely been entered upon as yet with advantage, and the relations of albuminoid nitrogen may yet add new chapters of the highest interest in the history of this element. It has been deemed highly probable on certain experimental data, that albuminous substances, like alkaloids, are built up through the transition of the pyridine compounds. On evidence just cited it may appear that the same bodies are broken down through the transition of the diazo compounds. Whatever may be in reserve for future chemistry, to come from the study of the proteids of food, its importance is sure to belong, in greater part, to the chemistry of nitrogen.

In the brief and inadequate review now concluded, an early mention was made of those first two steps that counted so much then for progress, the making of methylamine by Wurtz, and the proof of primary and secondary amines by Hofmann. Of these workers, the one died only three years ago, and the other is living as an active promoter of science. The advances made in the lifetime of these men bring a deep sense of gratitude to the heart of every chemist. We pay honor to them for the good works they in their days have done, and we have been grateful, with them, for the rich and beneficent fruits they in their lives have seen.

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ON THE CONSTITUENTS OF WILD CHERRY BARK (PRUNUS SEROTINA, EHRHART). By FREDERICK B. POWER and HENRY WEIMAR, Madison, Wis.

[ABSTRACT.]

THE bark of the wild cherry (*Prunus serotina* Ehrhart, *P. virginiana* Miller, *Cerasus serotina* Loiseleur) appears to have been first examined chemically by Stephen Procter[1] who inferred the constituents to be: "starch, resin, tannin, gallic acid, fatty matter, lignin, red coloring matter, volatile oil, hydrocyanic acid, salts of lime and potassa, and iron." The hydrocyanic acid was well identified by Procter, and the volatile oil was observed to be "extremely analogous in its properties to the essential oil of bitter almonds."

The next investigation of this subject was by William Procter, Jr.,[2] who proved that the volatile oil and hydrocyanic acid do not preëxist in the bark, but are formed from a principle "which acts as amygdalin, and a decomposing agent which, like emulsin, is rendered inert by ebullition."

It was formerly supposed that the bark also contained phlorizin, but this principle could not be found therein by Mr. Perot,[3] and the editors of the U. S. Dispensatory, xv edition, p. 1194, therefore express the opinion that "the tonic property must reside either in the portion of amygdalin which may remain undecomposed, in the pure volatile oil resulting from its reaction with water, or in some yet undiscovered principle." The correctness of these inferences the editors state, *loc. cit.*, would seem to be proved by an experiment of Professor Procter, "who found the bitterness of an extract of the bark to remain after it had been wholly deprived of amygdalin."

From the time the above mentioned investigations were made to the present day most of the commentaries and text-books on materia medica have continued to make the unqualified statement that wild cherry bark contains amygdalin and emulsin, notwithstanding the fact, as a perusal of the original papers referred to will show, that neither of these substances has as yet actually been isolated from this source.

It might, indeed, seem reasonable to conclude that, since wild cherry bark, in contact with water, affords benzaldehyde (bitter almond oil) and hydrocyanic acid, these bodies must be formed from principles identical

[1] Amer. Journ. Pharm., 1834, Vol. VI, p. 8. [2] *Ibid.* 1838, Vol. X, p. 197.
[3] *Ibid.* 1852, Vol. XXIV, p. 111.

with those contained in the bitter almond, which, as is well known, have already been isolated, and their chemical and physical characters definitely and accurately established.

This inference, however, is not necessarily correct, since Ritthausen and Kreusler[4] have shown that vetch seeds afford benzaldehyde and hydrocyanic acid, although they do not contain amygdalin; and a still more interesting example from the animal kingdom is presented by a myriapod belonging to the genus *Fontaria*, which, when irritated, diffuses the odor of hydrocyanic acid, and, upon distillation with water, affords the latter substance, together with benzaldehyde.[5] The substance which, in this instance, by the action of a ferment, affords these principles cannot be identical with amygdalin, since it is soluble in ether. It has also been proved that cherry-laurel leaves do not contain crystallizable amygdalin, although upon distillation with water they afford products analogous to those of the bitter almond.[6]

The conclusion that wild cherry bark contains amygdalin[7] appears moreover, independent of its botanical relationship with the bitter almond, to be based entirely upon the fact that Procter, by appropriate treatment, obtained a colorless aqueous solution, which, in contact with emulsin, developed hydrocyanic acid and benzaldehyde.

In the "Pharmacographia," second edition, p. 254, in connection with the subject of wild cherry bark, the authors make the more reserved statement that "the bitterness and odor of the fresh bark depend no doubt on the presence of a substance analogous to amygdalin, which has not yet been examined."

It was, therefore, with an endeavor to ascertain whether crystallizable amygdalin was contained in, or could be isolated from, wild cherry bark, as also to obtain some further information regarding the supposed distinct bitter principle, that the following preliminary investigation was undertaken.

1. Examination for Amygdalin.

One kilogram of the bark, in No. 40 powder, was digested with 95 per cent alcohol for half an hour on a water bath. The liquid was then filtered and the residue treated repeatedly in this manner until the filtrate was nearly colorless. This liquid was then distilled until two-thirds of the alcohol was recovered. The residue had a very dark color and a strongly astringent taste, due to the tannic acid. In order to remove the latter the liquid was digested with oxide of lead, subsequently allowed to dry with the latter on a water-bath, and afterward extracted with strong alcohol.

[4] Flückiger's Pharmakognosie, second edit., p. 954 and Jahresbericht der Chemie, 1870, p. 883.

[5] Flückiger, *loc. cit.* p. 955 and Ber. d. deutsch. Chem. Ges. 1883, p. 92.

[6] Jahresbericht der Pharm., etc., 1874, p. 197.

[7] Our references to amygdalin in this paper will be understood as referring to pure, crystallizable principle, $C_{20}H_{27}NO_{11}$ which may so easily be obtained from the bitter almond by the process of Liebig & Wöhler.

The filtered alcoholic liquid had a light green color, and still contained considerable tannin. It was therefore again evaporated, whereby considerable chlorophyll separated out, was treated with a second portion of oxide of lead and filtered. The filtrate now obtained was of a light brown color and gave but a slight reaction for tannin. It was evaporated to one-half its volume, when a small amount of resinous matter separated, which was removed by filtration. This filtrate, which was of a light yellowish color, developed a strong odor of hydrocyanic acid when mixed with an emulsion of sweet almonds. It was allowed to evaporate spontaneously until it ultimately assumed the form of a thick syrup, but separated no crystalline substance.

II. Examination for Emulsin.

Five hundred grams of the bark, in No. 40 powder, were macerated with cold 95 per cent alcohol for twenty-four hours, in order to extract as much as possible of the amygdalin or other principle which would react with the emulsin when subsequently treated with water. The alcoholic liquid was filtered off, and the residual bark dried without the aid of heat. The bark was then macerated for twenty-four hours with cold water, when a slight odor was developed indicating that the amygdalin-like principle had not been completely removed by the previous treatment with alcohol. The aqueous liquid was now filtered, and to the filtrate a large volume of alcohol was added which produced a flocculent, whitish precipitate. This was collected, dried without the aid of heat, and then brought in contact with an aqueous solution of pure, crystallized amygdalin, but no odor of hydrocyanic acid was developed. This experiment would indicate that the peculiar ferment principle contained in wild cherry bark is not identical with the emulsin of almonds, or at least that it is not easily obtained by an analogous process. Its separation therefore still remains to be accomplished.

III. Examination for a Bitter Principle.

Since Procter, as previously stated, found the bitterness of an extract of the bark to remain after it had been wholly deprived of the so-called amygdalin, an experiment was made to ascertain the presence of a distinct bitter principle.

A portion of the bark which had previously been extracted with warm alcohol was digested with water for half an hour on a water-bath and filtered. The filtrate had a slight odor of hydrocyanic acid, indicating that a small amount of the amygdalin-like principle had escaped extraction by the alcohol. The aqueous filtrate was now precipitated by basic lead acetate, filtered, and the excess of lead removed from the filtrate by hydrogen sulphide. The filtrate from the lead sulphide was evaporated to a small volume on a water-bath. It was strongly acid, owing to the acetic acid formed in the liquid through the decomposition of the lead salt, but without any marked bitterness. Tannic acid produced in the liquid a very slight precipitate, which was so small that it did not admit of further investigation.

An attempt to isolate the bitter principle of wild cherry bark was also made some years ago by Mr. J. L. Williams[8] who pursued a different process, but which was not attended with very satisfactory results.

It is quite evident from these results that the bark does not contain any appreciable amount of a bitter substance, which, like most representatives of the class of so-called "bitter principles," is precipitated by tannic acid. On the other hand, experiments, to be subsequently described, lead us to conclude that the bitterness is due to another peculiar, crystallizable principle, which is obtained in quite a different manner.

IV. *Second Examination for Amygdalin.*

Since the first endeavor to isolate crystallizable amygdalin from the bark was unsuccessful, another experiment was made, based, with necessary modifications, upon the process employed by Liebig and Wöhler[9] for the preparation of amygdalin from bitter almonds.

One kilogram of the bark, in No. 40 powder, was exhausted on a water-bath with hot 95 per cent alcohol. The liquid was then filtered and distilled until five-sixths of the alcohol had distilled over. The alcoholic residue was then shaken with half its volume of ether, and allowed to stand for twenty-four hours, but, as no precipitate formed, the ether was allowed to evaporate from the mixture spontaneously. The residual liquid was then treated with a solution of gelatin in order to remove the tannin. This formed a dark, leathery precipitate, which was filtered off, and the filtrate evaporated on a water-bath to one-third its volume. The excess of gelatin was removed from this liquid by means of strong alcohol, the precipitate filtered off and the alcohol removed by evaporation. A small portion of the liquid was now tested with an emulsion of sweet almonds, when a strong odor of hydrocyanic acid was developed. The entire liquid was then evaporated on a water-bath to a small volume, and placed in a desiccator over sulphuric acid to ascertain whether any crystalline substance could be obtained. After standing for twenty-four hours the liquid became thick and syrupy, and was found to contain considerable quantities of sugar. Since the latter substance could easily prevent the crystallization of any other principle, the first step was to effect its removal. Before doing so, however, a preliminary experiment was made with a solution containing pure, crystallized amygdalin, grape sugar and yeast, in order to determine whether the process of fermentation would destroy the amygdalin. This was found not to be the case, and therefore the syrupy liquid obtained from the bark was treated with yeast, and the sugar completely removed by fermentation. The fermented liquid had an odor of hydrocyanic acid, and afforded a strong reaction for this substance with Schönbein's test. It thus seemed evident that a little of the principle contained in the liquid had become decomposed by the action of some albuminous substance of the yeast. The filtered liquid, however, when tested with an

[8] Amer. Journ. Pharm. 1875, p. 53.
[9] Husemann-Hilger, Die Pflanzenstoffe, 2nd edit., p. 1018.

emulsion of sweet almonds, still developed a strong odor of hydrocyanic acid. It was now allowed to evaporate in a desiccator over sulphuric acid, but afforded ultimately a thick, syrupy liquid from which no crystalline substance could be obtained, although it was perfectly free from sugar.

The endeavors to obtain crystallizable amygdalin from wild cherry bark are thus seen to have been attended with negative results. The substance contained in the bark, which, in contact with emulsin, affords benzaldehyde and hydrocyanic acid, could only be obtained in an amorphous, extract-like form, resembling more closely in its general properties the so-called laurocerasin[10] of cherry-laurel leaves, to which the formula $C_{40}H_{67}N_{30}O$ has been assigned.

V. A Fluorescent Principle.

The syrupy liquid above described, from which the sugar had been completely removed by fermentation, was found, upon the addition of alkalies, to develop a handsome and intense bluish fluorescence. The liquid was shaken with ether which took up the fluorescent principle and left it upon spontaneous evaporation in the form of small, needle-shaped crystals. They were purified by recrystallization from ether, and were thus obtained quite colorless. The crystals are sparingly soluble in cold water, but dissolve readily in hot water. The aqueous solution, even when very dilute, shows a handsome blue fluorescence, which is much intensified on the addition of ammonia or a fixed alkali and is destroyed by acids, but may be again developed upon supersaturation with an alkali. The crystals have no odor, but possess a very bitter taste. They fuse at about 158° C. They give no reaction for sugar until after heating with a dilute acid, thus indicating the substance to be a glucoside.

Mr. R. Rother[11] has also recently directed attention to this fluorescent principle, which he obtained by a somewhat peculiar and very circumstantial process, in apparently small amount. It therefore seems proper to state that we had obtained the fluorescent principle in a crystalline form several months prior to the publication of Mr. Rother's paper. The latter gentleman states regarding it that, "judging from its crystalline form it does not appear to be mandelic acid, a decomposition product of amygdalin. It may, however, be au analogue, or a substituted derivative of it. This conjecture leads to the legitimate question, whether or not it is amygdalin as such, from which the benzoic aldehyde and cyanhydric acid of syrup of wild cherry result."

The conjecture regarding the identity of this fluorescent principle with amygdalin may be at once dismissed, for our investigation leads us to believe that wild cherry bark does not contain crystallizable amygdalin. The latter substance is furthermore insoluble in ether, and perfectly devoid of fluorescence in either a purely aqueous or an alkaline solution. The fluorescent principle also appears to differ in some of its properties from

[10] Flückiger's Pharmakognosie, 2d edit., p. 725, and Jahresbericht der Pharm., etc. 1874, p. 197.

[11] Amer. Journ. Pharm., 1887, p. 286.

aesculin, although the melting points of the two substances are quite closely connected.

To summarize the results of this investigation, which we can only regard as preliminary to a more complete study of the subject, we may form the following conclusions:

1. That wild cherry bark does not contain crystallizable amygdalin, but an analogous substance, possessing a somewhat bitter taste, and as yet only obtainable in an amorphous, extract-like form. As before observed, it appears to be more closely related to the so-called lauro-cerasin of cherry laurel leaves.

2. That the ferment principle contained in the bark is not identical with the emulsin or synaptase of almonds, or, at least, cannot be isolated by an analogous process.

3. A fluorescent principle exists in the bark which crystallizes in colorless needles and has the characters of a glucoside. This substance, whose elementary composition and chemical properties we hope more fully to determine, also appears to represent the peculiar bitter principle of the bark.

University of Wisconsin, July, 1887.

ON THE FATTY ACIDS OF THE DRYING OILS. By Prof. L. M. NORTON, Mass. Institute of Technology, Boston, Mass.

[ABSTRACT.[1]]

LINOLEIC acid is first discussed and the probability that it possesses the symbol $C_{18}H_{32}O_2$ is discussed. The author then shows that the fatty acids of the drying oils are either volatile in vacuo or give volatile products. The properties of the volatile product to be obtained from linoleic acid are given together with the analysis symbol $C_{20}H_{36}O_2$ and a similar series of experiments upon ricinoleic acid are also described. It seems likely that this method of examining these drying acids will shed much light on the composition of the drying oils. It seems certain that the constitution of the drying oils is complex and that the simple acids previously supposed to exist in them are mixtures of several acids and that among them is one important one, $C_{20}H_{36}O_2$.

PERCENTAGE OF ASH IN HUMAN BONES OF DIFFERENT AGES.[2] BY Prof. WILLIAM P. MASON, Rens. Poly. Inst., Troy, N. Y.

[ABSTRACT.]

THIS paper is little more than a table, giving per cent of inorganic material in the bones of subjects, whose age, sex, color, nationality, occupation, habits and fatal disease, are more or less known. The chemical work

[1] Published in the Berichte der deutscher chemischen Gesellschaft.
[2] Whole report sent to London Chem. News.

has been supplemented by breaking columns of the bones (of standard size) on a testing machine. The investigation was originally started with a view of determining the cause of the increase in brittleness with advancing years. Nothing more is attempted at this time than a report of progress, but enough bones have been examined (fifty) to show that the popular notion that the earthy constituents increase in amount with age, is without foundation. The work is unfinished, but the report on it is made so far as it has been pursued, in view of the *exceeding* difficulty of obtaining supplies; and, also, in part, on account of loss of material through burning of the laboratory. It will take some considerable time to collect new specimens.

AMOUNT OF MOISTURE LEFT IN A GAS AFTER DRYING BY PHOSPHORUS PENTOXIDE. By Prof. EDWARD W. MORLEY, Cleveland, Ohio.

[ABSTRACT.]

Two experiments have been made by drying air with P_2O_5, and then passing it through a weighed apparatus where the air is first slightly moistened, then expanded, and again dried by P_2O_5. The loss of weight, if any, in this apparatus, is due to the amount of moisture remaining in the volume added to the air by expansion. In an experiment where this increase was about 1700 litres, the loss of weight was less than $\frac{1}{20}$ mg.; in an experiment where the increase of volume was 2600 litres, the loss of weight was rather more than $\frac{1}{20}$ mg.

If we could consider the figures as exact, they would show that $\frac{1}{4}$ mg. moisture is left in 10,000 litres of air after passing, 75 litres an hour, through a column of P_2O_5 2 cm. in diameter and 8 cm. long. But it is obvious that the experiments fail to prove that any moisture is left unabsorbed, and do prove that, if any, it cannot be detected with any probability in 4300 litres of a gas.

IMPROVEMENT IN STAND FOR ELECTROLYSIS. By Prof. WILLIAM HALE HERRICK, State College, Pa.

[ABSTRACT.]

ADDITION to stand described by v. Malapert, in Zeits. Anal. Chem. **26**, 56, allowing the use of platinum dishes for electrolysis, and the heating of solutions therein.

CAUSES, PROGRESS AND CURE OF THE EPIDEMIC OF TYPHOID FEVER AT MT. HOLLY, N. J., JUNE, 1887. By Dr. ALBERT R. LEEDS, Hoboken, N. J.

[ABSTRACT.]

THE private corporation supplying Mt. Holly, a town of six thousand inhabitants, with water, located the intake of its pumping-station upon a small mill-race connected with Rancocas Creek. When the mill was running, water passed through this race, otherwise not. The intake was a crib placed in an angle along this race, and out of the little current flowing therein. The suspended mud settled in this crib and flowed down an inclined pipe into the pump-well of the pumping-engine, and was drawn up and discharged with the water in the town. The water in Rancocas Creek is at all times coffee colored, from the dissolved peat derived from cedar swamps in its drainage-basin, but has not been known to originate gastric disturbances in consequence. Prior to the recent epidemic there had been typhoid fever in Smithville, a village located on Rancocas Creek, four miles above Mt. Holly. More especially there had been a fatal case in a house, which communicated by a drain pipe directly with the creek, this drain being less than 100 feet in length, and all the dejecta of the patient being cast into the drain without prior disinfection. This case had continued until May, and in the latter part of that month, typhoid fever broke out in Mt. Holly, those attacked in every instance using the Rancocas Creek water.

As the circumstances, the period of incubation, and the lack of other equally plausible explanations, pointed to the defilement of the water by infected sewage at Smithville, I compared the analyses of the water, both chemical and biological, sample I being taken above Smithville, and sample II from the intake of the Mt. Holly pumping-station.

	I	II
Free ammonia,	0.002 pts. per 100000	0.006 pts. per 100000
Albuminoid ammonia,	0.015 " " "	0.0155 " " "
Oxygen required to oxidize organic matters,	0 45 " " "	0.55 " " "

Though in each case the figures indicate larger percentages than should be present in water of satisfactory quality, and though that taken from the intake shows manifest contamination, yet the chemical analysis alone would have been quite inadequate. But by gelatine-peptone cultures, I found there were present in the Smithville sample, only fifty bacteria per cubic centimeter, while in the sample from Mt. Holly there were 8000 per cubic centimeter. Very remarkably the fifty were, as far as could be determined, of one species,— the common *Bacterium termo;* while the 8000 were mostly one, but that of a different species, the *Bacterium lineola*. These are scavenger-bacteria, and I do not by any means assert that these bacteria were the specific bacteria of the typhoid infection. It is possible

these had all gone past the intake at the time when I collected the samples, July 21. An examination of the dejecta of two patients showed an immense number of a straight bacillus, 0.006 mm. in length and 0.0002 mm. in breadth. The small intestine, obtained from an autopsy, revealed a vast number of micrococci. The bacillus of Eberth, supposed by some to be the specific bacillus of typhoid, I could not find. The most surprising result, and one of the greatest practical importance, was this: — On adding one half a grain of alum to the water taken at the Mt. Holly intake, the peat was precipitated, the liquid becoming colorless and limpid. On drawing up in a pipette a sample of this clarified water, it was found to contain only eighty bacteria per cubic centimeter. On filtering through a double thickness of sterilized filter-paper, the filtrate was found to contain no microbes whatsoever, so far as the method of gelatine-peptone cultures was conclusive on this point. I would, therefore, advocate the use of this minute amount of alum, which is too small to be detected by the taste, and which moreover is subsequently precipitated in combination with the peat, as an effectual method of sterilizing such waters, and coupled with proper filtration, of rendering them wholesome and safe for drinking purposes.

A NEW METHOD FOR THE PREPARATION OF ANHYDROUS ALUMINUM CHLORIDE. By Prof. C. F. MABERY, Cleveland, Ohio.

[ABSTRACT.]

WHEN dry hydrochloric acid gas is passed over an alloy of copper and aluminum heated below redness, the aluminum is completely converted into the chloride while the copper is hardly affected. The formation of the anhydrous chloride proceeds most satisfactorily when the alloy containing from fifteen to forty per cent of aluminum is pulverized and mixed with fine charcoal to prevent the copper from uniting in a solid mass. By this method anhydrous chloride may be obtained free from iron or silicon. The anhydrous chloride is also formed when dry hydrochloric acid gas is allowed to act upon aluminum as it is reduced from the oxide by an electric current.

THE ACTION OF AROMATIC AMINES UPON CERTAIN SUBSTITUTED UNSATURATED ACIDS. By Prof. C. F. MABERY, Cleveland, Ohio.

[ABSTRACT.]

THE vigorous action that the aromatic amines exert on the substituted acrylic and propiolic acids results in the elimination of the halogens and frequently of the carboxyl group. With aniline in alcoholic solution, brom-

propiolic acid gives a product which is shown by analysis to have the formula, $C_{14} H_{14} N_2$. This substance forms a chloride $C_{14} H_{14} N_2 Cl$ and a platinum salt $C_{14} H_{16} Pt Cl_6$. Its melting point is 134° which shows that it is not diamido stilben (melting point 170°) with which its empirical formula appears to be identical. Analogous products are formed by the action of the toluidines upon brompropiolic acid. Paratoluidine gives a product with the formula $C_{16} H_{18} N_2$. It forms a chloride $C_{16} H_{19} N_2 Cl$ and a platinum salt $C_{16} H_{20} H_2 Pt Cl_6$. This substance melts at 116°. The products of the reactions with ortho- and meta-toluidines and with other amines await examination; also those of similar reactions which take place with the substituted acrylic acids.

CONSTITUTION OF THE SULPHUR COMPOUNDS IN CRUDE PETROLEUM OILS. (Preliminary notice). By Prof. C. F. MABERY, Cleveland, Ohio.

[ABSTRACT.]

THE sulphur compounds in crude petroleums distil at all temperatures in the process of refining, although we have found by analysis of the different fractions that they collect in the largest quantity between 200° and 300°. They are not extracted in any considerable quantity by alcohol, this alcoholic extract usually containing about one-third of the sulphur in the crude oil. As is well known strong sulphuric acid removes the sulphur compound to a large extent from the crude oil with the formation as it appears of a sulpho-acid. Upon neutralization of the acid with plumbic carbonate a lead salt remains in solution and it may be recovered by evaporation to dryness on the steam bath. This lead salt appears to be quite unstable and at higher temperatures it is decomposed with the formation of plumbic sulphide.

These sulphur compounds are at present under examination.

POSITIVE AND NEGATIVE UNITS OF VALENCE. By Prof. ALBERT B. PRESCOTT, Ann Arbor, Mich.

[ABSTRACT.]

A discussion of some features of a working theory consistent with the use of positive and negative "bonds" in the notation devised by O. C. Johnson[1] for equations of oxidation. Looking at chemism as a union or capacity for union of opposites—a union by the positive action of one atom with the negative action of another atom—we may consider valence to be a numerical measure of the exercise of chemism. This measure,

[1] 1880: *Chem. News*, 42, 51.

then, will be, first, as to the extent of chemism, expressed by the number of units of valence; and, second, as to the polarity of chemism, denoted by these units being positive or negative, in a relative sense[1]. All the valence units of an atom, as related to other atoms in a molecule, may include both positive and negative units. It is only the algebraic *sum* of the positive and negative units of valence of any element (or atom in combination) that is taken into account in Professor Johnson's notation. This sum of the positive and negative units should not be mistaken for the entire number of different units of valence, the latter number being all required for constitutional formulæ.

ANALYSIS OF TWO MANGANESE MINERAL WATERS. By FRED. G. NOVY, Ann Arbor, Mich.

[ABSTRACT.]

THE paper presented the results of the analysis of two mineral well-waters from Kennedale, Texas. These waters are interesting because of the large amount of manganese sulphate which they contain. One contains 15.31 grains per gallon of that salt. This represents the largest amount of manganese reported upon as being present in any mineral water of the United States. A short comparison is made of the quantities of manganese salts contained in other springs of this country.

SOME HIGHER HOMOLOGUES OF COCAINE. By F. G. NOVY, Ann Arbor, Mich.

[ABSTRACT.]

THE paper embodies the study of some of the derivatives of cocaine or methyl benzoylecgonine. The compounds described are four in number and are as follows: ethyl benzoylecgonine, monobrom ethyl benzoylecgonine, propyl benzoylecgonine and isobutyl benzoylecgonine.

The first-named compound is the ethyl esther of benzoylecgonine. It recrystallizes from alcohol in large, clear monoclinic prisms which melt at 107°–108°. It forms easily crystallizable salts. The hydrochloride crystallizes in beautiful, colorless needles or prisms and is readily soluble in water and alcohol; insoluble in ether. Its behavior to reagents is given in detail.

The second compound named above is obtained by heating benzoylecgonine with ethylene bromide and alcohol in a sealed tube. The free alkaloid is colorless syrup. The hydrochloride is likewise amorphous.

[1] C. J. REED, On positive and negative valence in classification under the periodic law, 1886: *St. Louis Acad. Sci.*

The third compound described, or propyl benzoylecgonine, crystallizes in fine colorless prisms or silky needles. It melts at 78°–79.5° and solidifies again at 65°. The hydrochloride is ordinarily in a syrupy condition, but when kept for some time over sulphuric acid, it yields a mass of fine, white crystals.

The isobutyl derivative, prepared like the preceding compounds by heating benzoylecgonine with isobutyl iodide and the corresponding alcohol in a sealed tube at 95°, crystallizes from alcohol in short, colorless prisms which melt at 61–62°. The hydrochloride solidifies over sulphuric acid to a hard yellowish glassy mass.

All these compounds possess a bitter taste and anæsthetic properties.

ON THE OCCURRENCE IN NATURE OF A COPPER ANTIMONIDE. By Prof. T. H. NORTON, University of Cincinnati, Ohio.

[ABSTRACT.[1]]

THE author describes a large deposit of copper antimonide recently discovered in Asia Minor near Mytilene. The mineral is of a silvery color, very lustrous, and has a specific gravity of 8.8. The formula is $Cu_{11}Sb$. This is the second antimonide found in nature, silver antimonide being the only other thus far known. Its purity and accessibility render it probable that the mineral will be susceptible of advantageous metallurgical treatment.

A NEW APPARATUS FOR FRACTIONAL DISTILLATION. By Prof. T. H. NORTON, University of Cincinnati, Ohio.

[ABSTRACT.[1]]

THE new apparatus is based on the principle of a rapid separation of vapor from condensed liquid in the upward current of a still, in opposition to the ordinary principle of a thorough washing of a current of vapor in the products of partial condensation, as exemplified in the ordinary types of laboratory distilling apparatus. Experimental data are given, showing that the fractionation accomplished by the use of the new type is fully as effective as that obtained by the use of the older forms.

[1] Published in Amer. Chem. Journ.

Certain alloys of calcium and zinc. By Prof. T. H. Norton, University of Cincinnati, Ohio.

[Abstract.[1]]

The method of Caron for preparing a zinc-calcium alloy by heating together mixtures of zinc, sodium and calcium chloride was examined with the view of ascertaining the limits of the amount of calcium which could be obtained by this means in the metallic form. It was found that the method is not capable of yielding alloys containing more than 7 per cent of calcium. Alloys containing 5–6 per cent are very brittle, do not lose their lustre in the air and melt at 640°.

On the salts of benzene-sulphonic acid with the amines. By Prof. T. H. Norton, University of Cincinnati, Ohio.

[Abstract.[1]]

In view of the fact that no derivatives of the amines and the aromatic sulphonic acids are thus far known, the author has prepared the salts formed by benzene-sulphonic acid with twelve of the more important amines. These salts are all anhydrous and crystallize readily. Those formed with the fatty amines are very deliquescent. The author has examined the applicability of Pearson's method for the determination of sulphur, to the analysis of sulphonates, and finds that in point of accuracy, simplicity and economy, it is far superior to the methods now in vogue.

Some new metallic salts of benzene sulphonic acid. By Prof. T. H. Norton, University of Cincinnati, Ohio.

[Abstract.[1]]

The new compounds described include the mercurous, cadmium, manganese, nickel and cobalt salts of benzene-sulphonic acid. All crystallize finely except the mercurous salt.

On the amine salts of para-toluene-sulphonic acid. By Prof. T. H. Norton, University of Cincinnati, Ohio.

[Abstract.[1]]

The author describes a series of ten amine salts of para-toluene-sulphonic acid. They all crystallize without water of crystallization. Those containing animes of the fatty series are exceedingly deliquescent.

[1] Published in Amer. Chem. Journ.

On the action of silicon fluoride on acetone. By Prof. T. H. Norton, University of Cincinnati, Ohio.

[Abstract.[1]]

Acetone absorbs silicon fluoride to the extent of 45 per cent of its own weight. On fractionating the product, two liquids are obtained, both boiling between 90° and 100°, but non-miscible. One is lighter than water, easily decomposed and seems to be a compound of acetone with an exceedingly small amount of silicon. The other has a specific gravity of 1.36, contains but little carbon and a large amount of fluorine.

On the limits of the direct bromination of acetone and on the action between ammonium sulphocyanide and monobromacetone. By Prof. T. H. Norton, University of Cincinnati, Ohio.

[Abstract.[1]]

When bromine is added slowly to ice cold acetone, the bromine is substituted for hydrogen, until a liquid is obtained containing about equal proportions of monobromacetone and dibromacetone. Beyond this point decomposition accompanies the further action of bromine. A supposed additive product, $C_3 H_5 ClO Br_2$, mentioned by Linneman is shown to consist merely of monobromacetone and hydrobromic acid Monobromacetone, when exposed to the action of ammonium sulphocyanide, does not give rise to sulphocyan-propimine as is the case with its homologue monochloracetone.

On the action of chlorine on acenaphthene. By Prof. T. H. Norton, University of Cincinnati, Ohio.

[Abstract.[1]]

Dry chlorine attacks acenaphthene readily in the cold, giving rise to trichlor-acenaphthene, a non-crystallizable liquid of unstable nature. Before complete saturation by chlorine, this liquid possesses brilliant blue fluorescent properties, which are, however, lost before the operation is complete.

[1] Published in Amer. Chem. Journ.

ON THE URANATES OF AMMONIUM AND THE AMINES OF THE FATTY SERIES. By Prof. T. H. NORTON, University of Cincinnati, Ohio.

[ABSTRACT.[1]]

INSTANCES of normal composition among the uranates of the metallic bases are rare. The author has prepared uranates of the organic bases and finds them to be likewise not only of abnormal but of variable composition. This is likewise the case with ammonium uranate. The uranates of the amines of the fatty series are stable compounds, amorphous, insoluble, and ranging in color from canary yellow through orange to brown. The compounds with the aromatic amines are exceedingly unstable.

SOME NEW NITRO-PRUSSIDES. By Prof. T. H. NORTON, University of Cincinnati, Ohio.

[ABSTRACT.[1]]

THE new nitro-prussides obtained by the author are the cadmium, mercurous, nickel and cobalt salts. All are insoluble in water, and with the exception of the cadmium compound, extremely susceptible to decomposition, especially in sunlight.

COMPOSITION OF LOCKPORT SANDSTONE. By H. W. WELD, University of Cincinnati, Ohio. (Read by Prof. T. H. NORTON.)

[ABSTRACT.[1]]

THE author finds that the stratum of Medina sandstone, whence the famous Lockport sandstone is quarried, contains over 96 per cent of silica. Such a high percentage of silica and so small an amount of cementing material are comparatively rare.

ON THE DETERMINATION OF NITROGEN BY SODA-LIME. By Prof. W. O. ATWATER, Middletown, Conn.

[ABSTRACT.]

A SERIES of tests indicated that by long heating, especially if the temperature is high and there is much open space in the tube (channel as ordinarily recommended), there may be loss of nitrogen from dissociation

[1] Published in Amer. Chem. Journ.

of ammonia. Another series showed the decided danger of loss from incomplete ammonification, especially with channel and long continued heating. It is important to secure intimate contact of substance and decomposition products with soda-lime and to avoid very high temperature and long heating. A channel may cause serious error.

ON CHEMICAL CHANGES ACCOMPANYING OSMOSE IN LIVING ORGANISMS, ILLUSTRATED BY THE OYSTER. By Prof. W. O. ATWATER, Middletown, Conn.

[ABSTRACT.]

ANALYSES of oysters, as taken from beds in salt water and after "floating" in brackish water, showed that not only mineral salts but organic matters escape from the body of the animal during the sojourn in brackish water, while a much larger quantity of water is taken in. The process seems to be analogous to that by which the digested food passes through the walls of the alimentary canal.

ON THE PROCESSES OF SOIL FORMATION FROM THE NORTHWESTERN BASALTS. By Prof. E. W. HILGARD, Berkeley, Cal.

[ABSTRACT.[1]]

THE large area occupied by the so-called basalts of the northwest, and their obvious connection with "alkali soils," render a study of their transformation into soils of considerable interest. It was entered upon at my suggestion, by Dr. E. A. Schneider, the specimens having been collected by myself, near Rockland, opposite Dalles City, Oregon. The fresh rock, the sedentary soil formed from it, and the sediments into which it was resolved by mechanical analysis, were analyzed both by fusion, and by digestion with H CL as usually practised in soil analysis. The sediments represent, of course, rock more or less decomposed in proportion to their fineness.

Mineralogical analysis, by Prof. A. W. Jackson, shows the rock to consist chiefly of augite and plagioclase, with much magnetite, undifferentiated glass and minute disseminated prisms of apatite. It is therefore an augite-andesite. The soil is a reddish-ferruginous loam, of rather light

[1] Published in full in the Proc. of the Society for the Promotion of Agric. Science for 1887.

texture; contains 14.5 per cent of true clay, and sediments from 1 to 8 mm. hydraulic value form 44 per cent of its mass.

Comparison of the chemical composition (by fusion) of the fresh rock and whole soil shows in the soil an increase of 7.3 silica, partly due to atmospheric sand; alumina has increased only 2.5 (kaolinization); but half of the lime, seven-tenths of the magnesia, and four-tenths of the iron, have been removed in the weathering process. In contrast to this leaching-out of the less soluble oxides, the two alkalies K and Na have remained practically the same, gain and loss in the other ingredients nearly balancing each other.

The analysis of the several sediments confirms in general the above results; and the same is true of the analyses made by digestion with hot hydrochloric acid, of the same substances. It appears that in the coarser soil-sediments the soda percentage is actually *increased*, but decreases as the sediments become finer; while potash increases steadily toward the finer portions.

The general conclusions deducible from the investigation might be thus formulated:

1. The augitic ingredient of the rock is first attacked in weathering; the removal by leaching-out bears most heavily on the magnesia, next on lime and phosphoric acid, next on iron; but a portion of the latter (magnetite?) resists oxidation quite stanchly, and the soil remains highly ferruginous.

2. The weathering of the plagioclase progresses slowly, and is unaccompanied by any material leaching-out of the alkalies, which doubtless remain in zeolithic combination.

3. The latter fact and the increase of potash and diminution of soda in the finer portions of the soil (which especially serve the processes of vegetable nutrition) point to the conclusion that the setting-free of the sodium salts, which constitute the "alkali" of the basaltic region, is the result of *discriminative plant action on the zeolites* (potash being assimilated and soda rejected) rather than of mere weathering.

4. As to the general character of these "basalt" soils, they are marked by an abundant supply of potash (up to two per cent), lime and phosphoric acid, notwithstanding that the latter two have been reduced to about half in the process of soil-formation. But the fact that a very large proportion of phosphoric acid appears in the coarser portions of the sediments, becoming less and less in the finer ones, with only one-sixth of the total in the readily soluble condition in which it is extracted by Grandeau's process of humus-extraction, indicates that it exists in the soil largely in the form of the original apatite crystals.

5. Finally, the large amount of leaching-out accomplished in the process of soil-formation, especially as regards the iron oxides, seems to be incompatible with the present conditions of the arid climate, with its rainless summers and cold winters, so unfavorable to the processes of reduction and carbonate solution. These facts point to a change in climatic conditions since the time when the bulk of the soil was formed.

INDIRECT DETERMINATION OF CALCIUM. By Prof. WILLIAM HALE HERRICK, State College, Pa.

[ABSTRACT.]

PRECIPITATION by excess of solution of ammonium oxalate of known strength, in a flask with graduated neck. Solution allowed to stand and settle, in a warm place, as usual, till perfectly clear. Volume read off, after cooling; clear solution siphoned off, and remaining oxalic acid determined in an aliquot part by titration with $KMn\ O_4$.

ON THE DELICACY OF THE SENSE OF TASTE. By Dr. E. H. S. BAILEY and Dr. E. L. NICHOLS, Lawrence, Kansas.

[ABSTRACT.]

THIS is a continuation of one branch of the subject presented by us at the Philadelphia (1884) meeting of the A. A. A. S. Solutions of known strength of the following typical substances were made: 1. A bitter substance — quinine; 2. A sweet substance — cane sugar; 3. An acid substance — sulphuric acid; 4. An alkaline substance — bicarbonate of soda; 5. A saline substance — common salt.

Each of these solutions was diluted to form a series, each member of which was of one-half the strength of the preceding one. The bottles containing the solutions being placed without regard to order, the test was to separate into the five groups mentioned above.

The tests were made by 128 persons, 82 being males and 46 females. The average results are as follows:

I.—*Bitter.*

Males detected one part in 392,000.
Females " " " " 456,000.

II. *Sweet.*

Males detected one part in 199.
Females " " " " 204.

III. *Acid.*

Males detected one part in 2080.
Females " " " " 3280.

IV. *Alkali.*

Males detected one part in 98.
Females " " " " 126.

V. *Salt.*

Males detected one part in 2240.
Females " " " " 1980.

From these experiments it will be noticed that the sense of taste is much more delicate for bitter substances than for others, and least delicate for alkalies. The sense of taste also seems to be more delicate in females than in males. This rule also held when the same number was taken of each sex.

STANDARDIZING HYDROMETERS. By Prof. W. P. MASON, Troy, N. Y.

[ABSTRACT.]

SHOWING that Clark's method is the only one that should be used, and also that more is expected of the hydrometer, in point of delicacy than the nature of the instrument will permit. [Published in full in Jour. Am. Chem. Soc.]

NOTE ON ABSORPTION OF NITROGENOUS NUTRIMENT BY THE ROOTS OF PLANTS. By Prof. WM. MCMURTRIE, University of Illinois, Champaign, Ill.

[ABSTRACT.]

IN the present state of the science of agricultural chemistry, it is believed that the form of nitrogen most favorable to vegetation is that of the nitrates. And it is further a tolerably well settled belief on the part of many careful observers that this is the only form in which nitrogen may enter the plant through the medium of the roots. Yet there is no positive proof of this. Experiments have been made, affording results showing the apparent absorption and assimilation of ammonia and the amines. But in the experiments in question no precautions were taken to exclude microbes of nitrification from the soils used in the experiments. It is probable that through the agency of these microbes, the ammonias were first changed to nitrates, and that the nitrogen entered the plant in this form. Experiments devised to settle this point were described.

NOTE ON THE CHEMISTRY OF GERMINATION. By Prof. WM. MCMURTRIE, University of Illinois, Champaign, Ill.

[ABSTRACT.]

IT is generally understood that in the process of germination the seed first absorbs moisture, and then under the influence of heat and the oxygen of the air, the starch and fats are acted upon by diastase always present, and the albuminoids by peptone-forming substances, and that by these latter means all the material within the seed are brought into soluble condition in which they may be transferred to the young plant to be used and assimilated as they may be needed, and until the young plant is strong enough and sufficiently developed to take nutriment from the soil.

The experiments to be described show that this action within the seed is limited. Under its influence germination is begun, and the young plant

arrives at a certain stage of development; but, if the process be carried on in the absence of microbes in perfectly sterilized media and apparatus, the development is arrested, the seed maintains its form and is preserved, and it will so remain until microbes, by which it may be broken down by fermentation or putrefaction, are supplied. It is believed to follow from the results of these experiments that the action of diastase, etc., is limited, and that to complete the process of germination, presence of microbes is necessary.

THE SIGNIFICANCE OF "BONDS" IN STRUCTURAL FORMULAS. By Dr. SPENCER B. NEWBERRY, Cornell University, Ithaca, N. Y.

[ABSTRACT.]

THE author reviews briefly the criticisms of Lossen (Ann. der Chem. und Pharm. Vol. 204) on the prevailing use of the terms "Unit of Affinity," "Bond," and "Valence," and showed that the confusion and indefiniteness of which Lossen complains may be avoided by the adoption of the following definitions.

"Unit of Affinity," the power of one atom to combine with one other atom.

"Bond," the graphic representation of a unit of affinity.

"Valency," the maximum number of atoms, of any kind whatever, with which a given atom can combine.

The author urges the retention, for the sake of simplicity in our graphic notation, of the hypothesis of the invariable quadrivalence of carbon, and of the so-called "multiple linking" of carbon atoms, and cites examples to prove that if the latter method of writing be abandoned a number of additional isomers are theoretically possible, the existence of which is not indicated by experiment.

EXPERIMENTS GOING TO SHOW THAT SUCH FUNGI AS PENICILLIUM GLAUCUM CAN SUBSIST ON CARBON DIOXIDE. By R. G. ECCLES, M. D., Brooklyn, N. Y.

[ABSTRACT.]

THE fungi were cultivated in dilute phosphoric acid and solutions of alkaloids. No reduction in quantity of the acid or alkaloid occurred, the weights of the fungi increased steadily and thereby increased the total weights of the containing vessels.

THE SCIENTIFIC BASIS OF THE FEEDING OF INFANTS. By Dr. ALBERT R. LEEDS, Hoboken, N. J.

[ABSTRACT.]

I DESIRE to engage the attention of the Association upon this subject, both on account of its intrinsic vital importance, and because I believe that the existence of a scientific basis for the nutrition of infants has been satisfactorily established. This paramount importance is shown by the fate of infants under present conditions of nutrition:—out of every one hundred infants fed on mothers' milk, statistics show that about eight die at the end of the first year. Out of one hundred wet-nursed, eighteen die; and out of one hundred fed on "infant-foods," fifty-one, or more than one-half, die by the end of the first year.

The basis which I lay before you, was proposed as the result of an investigation made upon all infant foods at that time in use, the conclusions arrived at being published in the Transactions of the College of Physicians of Philadelphia for the month of May, 1883. I found that all of these foods, whatever might be their name or pretensions, belonged to one or the other of two great classes; they are either flour, plain, baked or cooked; or they are sugar admixed with cereals in some form, the so-called Liebig's foods. The great mortality among infants using these foods I have already spoken of, and the reason is obvious—they are physiologically as unsuited to the nutrition of a human infant, as grass and hay are to the nutrition of a calf deprived of cows' milk. Grass and hay consist of certain vegetable fibres, starches, sugars, fats and albuminoids. These are not digestible in the elementary digestive apparatus of the calf, and its mother does for it the work of digestion. Thereby, these vegetables are transformed and elaborated by the more perfect machinery of the adult animal, into a secretion which contains food previously digested and capable of affording instant nutrition to the calf. The same relation exists between the food of the human mother and the mother's milk. The latter, like cows' milk, contains no vegetable sugars, but instead, animal sugar, which is a body essentially different in its nutritive functions from cane sugar and grape sugar. It contains, moreover, not vegetable but animal caseine, which is likewise different.

The animal or milk sugar of cows' milk is identical with the animal sugar of mothers' milk and the fat is practically the same. But such is not the case with the caseine, the hard curd which cows' milk forms being indigestible by a human infant. Moreover, the amount of caseine in cows' milk is nearly twice that in mothers' milk. To overcome these difficulties is the *raison d'etre* of all the varieties of "infant foods." They are intended to prevent the formation of these hard clots by keeping asunder the particles of caseine by means of starch, dextrine, sugar, etc.

It became evident, in the course of experimenting with these "infant foods," and from a consideration of the terrible mortality attendant upon their use, that a new departure was urgently called for. Accordingly, four years ago, I proposed that we should abandon artificial foods altogether.

I prepared for infants deprived of mothers' milk, milk to which I gave the name of "humanized," since I found that it was, as far as could be ascertained, the same in composition and properties as mothers' milk. As a foundation for this work, I made analyses of eighty samples of mothers milk. They varied greatly in composition with the age, temperament, physical health, etc., of the mother. But when their average composition came to be compared with that of cows' milk, certain facts stood out very prominently. They were, first: that the amounts of sugar and fat in mothers,' were much greater than in cows' milk; second: that the caseine was much less; third: that the nature and proportions of the ash were not the same. But the most important difference was in the different digestibility of the caseine of the cows' milk. At the time that I was engaged upon this research, the treatment of cows' milk with artificially prepared pancreatic extract, in order to convert the caseine into a soluble peptone, was being largely resorted to. I was aware of this fact and of the experiments of Dr. Roberts of England upon this subject. But at that time, no one, so far as I am aware of, had studied the relative character of such peptonized caseine and the caseine of mothers' milk. On making such an investigation, I found that in properties and tests the two bodies behaved in precisely the same manner. Finding that the distinguished pharmaceutical chemist, Mr. B. T. Fairchild, to whose knowledge and skill the employment of pancreatic extract in this country and in England is principally due, could prepare a tryptic ferment which could be relied upon with certainty to effect the desired change in cows' milk, I made this tryptic ferment the basis of the so-called peptogenic powder. By diluting cows' milk with the requisite quantity of water, its percentage of caseine is lowered to the same amount as in mothers' milk. By the addition of cream, the percentage of fat is adjusted, and the heating of the milk for five minutes with the peptogenic mixture does the remainder.

The "humanized milk" thus prepared has already been the sole nutrition of many thousand infants, especially children of weak and disordered digestion, and I believe it to be a successful solution of the problem of infant nutrition.

A PROCESS FOR THE SEPARATION OF ALKALOIDAL POISONS FOR STUDENTS' USE. By Prof. ARTHUR L. GREEN, La Fayette, Ind.

A NEW COMPOUND, RICH IN CARBON, OCCURRING IN SOME PLANTS. By HELEN C. DE S. ABBOTT, Philadelphia, Pa.

THE CHEMICAL COMPOSITION OF THE JUICES OF SORGHUM CANE, IN RELATION TO THE PRODUCTION OF SUGAR. By Prof. H. W. WILEY, U. S. Department of Agriculture, Washington, D. C.

ON THE SUCCESSFUL PROTECTION OF THE EGYPTIAN OBELISK IN CENTRAL PARK, BY SATURATING ITS SURFACE WITH MELTED PARAFFINE WAX. By Prof. R. OGDEN DOREMUS, Bellevue Hospital and College, New York, N. Y.

METHOD OF PROTECTING THE "SOUNDING BOARDS" AND THE "ACTIONS" OF PIANOS, ALSO VIOLINS AND OTHER STRINGED INSTRUMENTS FROM INJURY BY EXCESSIVE HUMIDITY. By Prof. R. OGDEN DOREMUS, Bellevue Hospital and Medical College, New York, N. Y.

CRYSTALLOGRAPHY OF FATS OF MAN AND OF THE LOWER ANIMALS. WITH EXHIBITION OF PHOTOGRAPHS. By Dr. THOMAS TAYLOR, U. S. Department of Agriculture, Washington, D. C.

REPORT OF COMMITTEE.

THE COMMITTEE OF SECTION C OF THE A. A. A. S., appointed at the Buffalo meeting to consider and report a scheme for a Uniform Method of Stating the Results of the Analysis of Mineral and Potable Waters, submit the following report:

The great importance of a uniform method of stating the results of analyses of mineral and potable waters, in the place of the variety of methods now in vogue, was fully set forth and illustrated in the paper on this subject read before the chemical section of the Buffalo meeting and which suggested the appointment of this committee.

In order that any method of stating these results shall secure for itself general approval and adoption, your committee are of the opinion that it should deviate as little as possible from the most general present practice and should not do serious violence to that practice in any respect. As, for instance, while recommending the statement of the proportion of each basic element determined, and of most of the acidic or electronegative elements, there would appear to every one, doubtless, a certain degree of absurdity in giving the proportion of C instead of CO_2; and certain other exceptions to this general rule seem to be advisable.

Your committee are also of the opinion that one scale for both mineral and potable waters is unadvisable. The scale that would be desirable in order to avoid the use of too large numbers in stating the composition of a mineral water would necessitate the use of inconveniently small decimals in the statement of the composition of a potable water examined for sanitary purposes.

Your committee therefore recommend the adoption of two schemes, as follows, the first of which embodies many of the features of the scheme presented to the Washington Chemical Society by its Committee.

I. *Scheme for a mineral water.*

(*a*) That the composition be expressed in parts per thousand in weight.

(*b*) That the parts per thousand of each basic element, K, Na, Li, Ca, Mg, Fe'' (Fe_2), etc., be given, and of each acidic element, such as Cl, I, S, etc., that is combined directly with a basic element, or that may reasonably be supposed to be so combined, the rest of the acidic elements to be given in connection with all the oxygen of their salts, as usually written in our present empirical formulas, as SO_4, CO_3, PO_4, etc.

(*c*) That these constituents be arranged in electro-chemical order, the positive ones being given first.

(*d*) That the volume of O, CO_2 and H_2S expelled on boiling be given in cubic centimetres per litre of water.

(*e*) That the combination deemed most appropriate by the chemist making the analysis be stated both by names and by symbols.

II. *Scheme for potable waters examined for sanitary purposes.*

The composition shall be expressed in parts per million (milligrammes per litre) as follows:

Total solids
Chlorine
Nitrogen: expelled on boiling with $Na_2 CO_3$ . . . . . .
equals "free ammonia" . . . .
expelled on boiling with alkaline permanganate . .
equals "albuminoid ammonia" . . . . .
as nitrite . . . .
as nitrate . . . .
Organic matter (in terms of mgms. of oxygen . . . .
consumed by one million of water) . . . . . .
Hardness . . . .

The manner of expressing the results on organic matter must depend somewhat upon the method of its estimation. Your committee had this matter under discussion, but, concluding that it was beyond their province to offer any recommendation as to methods, they recommend provisionally the above statement as to the organic substance, and content themselves with suggesting that the whole matter of methods and details of the examination of water for sanitary purposes be referred to a new committee to report next year.

G. C. CALDWELL,
J. W. LANGLEY,
R. B. WARDER, *Committee.*
W. P. MASON,
J. A MYERS,

SECTION D.

MECHANICAL SCIENCE

AND

ENGINEERING.

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ADDRESS

BY

ECKLEY B. COXE,

VICE PRESIDENT, SECTION D.

An occasion like this, when an engineer, engaged in the active duties of his profession, but who is really more of a business man than a scientist, is called upon to preside over the deliberations of a body so distinguished, and so eminently scientific as the one that I now have the honor of addressing, must, of course, impress itself very strongly upon him, and give much food for reflection. His mind naturally turns back to review his professional life, from the time when he began as a student his technical education; many ideas, opinions and reflections, which have been more or less forgotten or pushed aside in the rush of business, come back, and again force themselves upon his attention: such, at least, has been the case with me.

As my life has been devoted exclusively to the mining of coal, and, as I have been engaged in no special scientific investigations like so many of those around me, I cannot offer for your consideration original observations or suggestions upon any important scientific subject to which I have specially devoted myself, but it seems to me that I might not unprofitably occupy your time at the opening of this session by asking your attention for a few minutes to some thoughts, which, during the last quarter of a century, have, from time to time, in a more or less desultory way, impressed themselves upon me, with reference to the subject of engineering.

Engineering is the youngest of the professions, and, with the exception of the military branch of it, may be said to have been practically unknown a century ago; there was, of course, much work now considered within its domain, which was done by archi-

tects and others, but, as a well-defined recognized calling, it may be considered one of the creations of the nineteenth century; and yet, it has made such great advances, has broadened so much, and is now being divided, and subdivided, in so many ways, that it is doubtful whether it can properly be considered any longer a single profession. I do not wish to discuss here the division into the mining, civil, mechanical, electrical, hydraulic and other branches; that has been done by other hands, much abler than mine. How deep, how important and how real these divisions are, is well shown by the large and flourishing societies which have sprung up and are devoting themselves, with so much vigor and effect to almost every one of them. But, within the last twenty-five years, another equally important change has been taking place which, it seems to me, is destined to produce, at least as great an effect as the subdivision, referred to above, upon the future of our vocation. Engineering is now no longer a profession only. It may be, also, a science or a business; that is to say, the student, when he enters college and takes the engineering course, may, with perfect propriety, look forward to being a man of science, a professional man, or a man of business, and it is not only very possible, but very probable, that he might make a success in one and a comparative failure in either of the other careers. Such, at least, has been my experience.

Let us pause for a moment and consider the exact meaning of the words engineer and engineering: they, as well as the word "ingenious" are derived from the Latin "ingenium," which in turn comes from the verb "gigno," to bring forth or produce; they involve, therefore, the idea of originating, of advancement, of development, of passing from the known to the unknown, from the certain to the uncertain, from that which has been accomplished to that which is desired. In other words, so far as their derivation is concerned, they involve the idea of evolution and progress; and we have but to look around us in any civilized country of the world to see how well this fundamental principle has directed the minds and hands of those engaged in the practice of the profession. This may be well called the age of engineering, as it is called the age of progress.

But we must remember that the engineer is not a creator; he never makes something out of nothing; he develops, enlarges, expands, evolves, sometimes, it is true, in special cases, to such a

great extent, or with such rapidity, that the result to which he attains may seem almost a creation to all but the closest observers, but this is a rare exception, not the rule; ordinarily, the progress is very slow, and sometimes almost disheartening. Very early in the history of engineering, in fact, almost before it could be considered a profession, it became evident that facts and scientific data, which could only be obtained by long, careful and laborious experiments, were absolutely essential to those practically engaged in the prosecution of engineering, that, however correct the reasoning, however brilliant the intellect, however careful the calculation, all would be useless, unless the properties of the material used, and the law of nature that would be likely to be called into play, have been carefully determined by the most thorough scientific investigation and experiment. There is no better way of impressing upon our minds how important, nay, how absolutely essential, such data and such investigations are, and of realizing how great has been the amount of scientific work that has been placed at our disposal, than to take up any engineer's pocketbook, not the best or the fullest, but one of the ordinary ones, and examine for one's self how much of what we use every day, and of what we now consider almost axioms, is the result of scientific study and experiment, and was unknown, or, at least, so little known and so uncertain, as to be practically of no value less than a century ago.

As the number of these original investigators increased widely, and as the data accumulated by them became more and more voluminous and valuable; and as the results of their labors were published in no one country and in no one language, but were to be found in the scientific journals and text-books of all civilized nations; much the greater part of these facts, so essential to every engineer in active practice, was accessible only to those who had sufficient means to procure the books and periodicals which contained them, or were so situated as to be able to use one of the great public libraries which were then much more rare than now. Even where the information was accessible to them, very few of those who really had the greatest need of it had sufficient time at their disposal to enable them to make use of the very valuable material, disseminated, as it was, so widely. Such a state of affairs could not, of course, exist for any great length of time.

There is a class of minds to be found in all professions which

are specially fitted for the work of gathering together exactly such data and of placing them in such a shape as to be readily accessible and in the most appropriate form for practical use. Sometimes, with this faculty or capacity is combined, with that of being able to deduce from such well-prepared tabulated statements of a large number of facts relating to some one natural principle, a general law contained in a few words or a comparatively simple formula by which most of the data in question can be expressed in a mathematical form. Newton's " law of gravitation" and Darwin's "law of the survival of the fittest" are among the highest evidences of this power. The mathematical discussion of such formula often leads to results of the highest importance when undertaken by such men, who, though far from common, are nevertheless to be found in all branches of natural science, and they are probably as well represented in the American Association for the Advancement of Science, as in any other school of scientists. I do not mean, of course, in absolute numbers, but in proportion to the comparative rarity of this type of mind. It is to these two classes of scientific workers that the profession of engineering practically owes its existence in its present state. Their remuneration, I am sorry to say, has been very meagre, that is, in a pecuniary point of view. Mentally, they have been undoubtedly well paid, for labor of this character brings probably the highest intellectual pleasure of which the human mind is capable. The pecuniary unselfishness of these classes of men has become proverbial; to the average man of the world it is absolutely incomprehensible.

Until a comparatively recent time, there was, except in a few special cases, but little provision made to aid these unselfish workers, and much of the best of this kind of scientific work was really done in poverty, by those, who, not only were not paid for it, but who really had to deprive themselves of many things we consider necessaries of life to obtain the means of carrying on their investigations. They were recruited from various sources: many began as teachers in the few technical and scientific schools that then existed; but, recognizing when instructing their classes the want of better and more accurate knowledge of certain physical phenomena, were induced, by their love of the subject, to endeavor, by experiment, to supply that need. Others, again, who, by some happy accident, had had their attention directed to physical science, passed from the laboratory to the lecture-room, and, through

a long and useful life, combined the two callings. Those, however, who, during their whole career, either as experimenters, compilers, or mathematicians (using the latter word for want of a better, to cover that class who have generalized and placed in a mathematical and exact form the result of the labors of others), confined themselves to their specialty, were generally considered by most men as good-natured, harmless and rather eccentric individuals, whose function in life they did not understand, and the valuable results of their mental labor they did not appreciate, although they might have an indistinct idea that, on some exceptional occasion, the information such men were accumulating might be useful.

The *practical engineer*, the engineer as the world understood it, was at first developed in the workshop or in the field; he may in some cases have begun with a little scientific training, but this was rarely the case. He was generally a man of broad, common sense with great capacity for work, open to conviction and with a strong desire to improve himself. His professional training was acquired chiefly in the active, practical work of his calling, but, whenever the occasion presented itself, he availed himself of whatever books on natural philosophy or special technical subjects came to his hand. He grew with his profession and helped to advance it. The careers of such men as George Stephenson and James Watt give, it seems to me, a good idea of the power of certain minds and of the development of which they are capable, even where circumstances have not been particularly favorable. The success of such men is often referred to, as showing of how little importance a scientific training is to the engineer. How often have I heard intelligent people, who have only examined the subject superficially, say, "Look at that man! he never had any college training, and see what he has accomplished; now, look at that other! he has had the very best educational advantages, and he has done absolutely nothing." But we all know that the very roughest manipulation may sometimes make an excellent tool out of a good piece of steel, while the most careful handling, the best workmanship, can never do that with a radically bad piece. The older members of the profession, those with whom I came in contact as a boy, when I first had my attention directed towards it, were almost without exception self-made, self-instructed, self-developed men, but "there were giants in those days."

The demand for men to undertake the direction of the great public works which were started in all parts of the United States, during the early part of the century, naturally brought such men to the front; there were no schools and colleges in which they could be instructed, nor were there any teachers capable of instructing them. They came to the front and maintained their position by mere force of brains. Among the younger men who were associated with them were some graduates of the few technical schools, mostly European, or of the scientific courses of some of the colleges, that were already beginning to realize the importance to the rising generation of a chance to prepare themselves for such a field of labor and to endeavor, as far as was then possible, to afford them the opportunity. When the good work was once started, the demand for the services of graduates of these colleges soon became too great for the supply; and schools, where technical instruction of the highest order is given, have been established all over the country, which is now dotted with institutions of this character, and the public works, throughout the whole United States, bear witness to the eminent abilities and thorough training of a host of their graduates.

The above, though a very brief and imperfect description of the manner in which the profession of engineering has grown during the present century is, in the main outline, correct.

Much of what I have said is the result of personal observation and much I have learned from conversing with the older members of the profession with whom I have come in contact since I was a boy. As long as I can remember, nothing ever gave me more pleasure than to listen to the stories of how the pioneer engineers of our country encountered and overcame great difficulties with the very imperfect and limited appliances they had at their command.

At the present day engineers, no matter what may be the special branch to which they are devoting themselves, can be divided into three general classes: The first class includes those engaged in purely scientific and experimental work; and, in it, we find, not only the original investigators, the compilers and the mathematicians, but, also, those who have charge of the experimental and physical laboratories of the great railroads and industrial establishments of the country. These form a body of ever-increasing importance not only in their number, but also in the value of their work, which is, in a certain sense, similar or rather analogous to that of the

analytical chemist. Their duties are peculiar in this respect, that, as far as they are personally concerned, commercial considerations do not, at least to any great extent, enter into them; they have little or nothing to do with the management of men nor with the question of the best utilization of their labor; they are rather critics of other men's work than directors of it. For example, they are not required to produce at a given cost a certain quality of iron or steel, but to determine the physical and chemical properties and the relative values of the different kinds of steel and iron that are produced; to decide whether a given specimen is what it pretends to be or not; to tell whether its qualities are such as to fit it for any particular special use. But their functions do not cease here. They discover, by experiment, new uses for old products and new products for old uses; they investigate scientifically the new problems that are constantly arising in the fields in which they are engaged and which it would be impossible for engineers, engaged in the practical direction of establishments of this kind, to work out, without interfering, very seriously, with those important duties which require their attention at all times.

The second class, which is a very large and important one, includes those who formerly constituted almost the whole body of engineers and who more nearly answer to the commonly received idea of the profession. The type of this class is the *chief engineer of a railroad;* he is the scientific adviser of the managers of the road. They decide what work is to be done or what it is advantageous to produce, what railroads it is commercially desirable to build; but it is his function to examine and advise them as to the various routes that may be adopted, giving, in detail, the particular advantages of each route, as to its cost of construction and of maintenance and of the greater or less expense of working it; he is supposed to investigate and report upon the different systems of bridges, rails, ties, etc.

If the managers have decided to build a road or a furnace, or if it has been determined to open a mine, it becomes his duty to supervise the preparation of the plans and the laying out of the work; if the actual construction is given out by contract, to see that the terms of the contract are carried out strictly, that only as much money is paid therefor at the times and under the conditions as was originally agreed upon, and that the material and work in all respects is of the class which it was decided that it should be.

But if, as is sometimes the case, the work is not let by contract, but is built by the company themselves, his duties become still more onerous and complex. He must then see, not only that the work is properly done, but also that just wages are paid; that competent men are employed; that suitable material is used; that they are properly utilized from a mechanical standpoint; that the price paid for them is the lowest compatible with good quality, and that finally everything is done so as to produce the best result for the smallest amount of money. For this he needs not merely a broad and thorough technical education, but good common sense, a knowledge of men and business experience.

The third class, which is of comparatively recent origin, is becoming more and more important and promises in the future to relieve those of the second class from much of their uncongenial duties, and comprises what may be called business or contracting engineers. I may probably best make myself understood by an example. Twenty-five or thirty years ago, if a railroad company wanted to build a bridge, unless it was a very small one, the chief engineer would have the ground carefully surveyed and examined; would have plans prepared in his office; would buy the material from different parties and have them properly worked up and the bridge erected under his own supervision. Now, the case is different; he would practically do nothing, except in very rare instances, but ask for bids for a bridge to be built of a given height and span under certain specified conditions over a valley or river, which would be capable of sustaining a given moving load. He would, if his company were able to pay for it, have no trouble in having this done by contracting engineers for a lump sum under a guarantee that it would be perfectly satisfactory, although each bidder would prepare his own plan for the structure. This applies not only to bridges, but to almost any other engineering work that is not of a very special character; in fact, it is not an uncommon thing for a contract to be made to construct and deliver a railroad built and equipped in a specified manner for a certain sum of money, or even for a certain amount of stock and bonds. Many of the blast furnaces recently erected by new companies have been built in this way. Some of the brightest minds in the profession are now engaged in this business, and it seems destined to become a more and more common way of doing work of this character. Where the contracting engineer is a man of ability

and character, it is a most satisfactory method both to the man doing the work and the one paying for it. This change, which is gradually being made in the duties of the profession, attracted my attention some years ago, but of late it has been so marked that I have almost unconsciously been giving a great deal of thought to it. It seems to me that it is worthy of the careful consideration of all of us, whether we are teachers, consulting engineers or men of business. If the fact be such as I have stated, if engineering be broadening and covering almost the whole field from pure science to pure business; if two young men who are members of the same class in a technical school, and following the same course of instruction be destined to such different duties, though they may both become in name engineers, is it not time for us to pause to examine the whole field of technical education, to study carefully the mental requirements and training of those who are to devote themselves to each of these three branches of what is now called engineering? As we all know, there has been for the past ten or fifteen years, a very active, vigorous and interesting discussion of that most important subject, "technical education." Men of ability and of experience, who have given much time and thought to the question, differ as widely as they did ten years ago as to the proper relation of theory and practice in the training of the young engineer. They are not in accord as to whether a student should do practical work before, during or after his collegiate course. There are many advocates of each plan, but among those who apparently have had the best opportunities of judging, there is, as yet, no agreement as to what advice should be given to a young man wishing to enter upon a technical career. No matter what plan may be suggested, there are always examples, both of the good and bad effects, of adopting that system which are constantly being brought forward. One of the most pleasant and hopeful features of the discussion, however, is the great interest that is felt in it by the older members of the profession, and the amount of time and thought that they are not only willing but anxious to give to it when we consider how little leisure they generally have for such work. However, notwithstanding the fact that so many able and educated minds, which have been trained to the most scientific and logical treatment of a vast range of subjects, have been so long trying to solve the problem, they seem as yet far as ever from coming to any agreement

as to the proper relations of theory and practice in technical education. Like many of you, I have also given some attention to the question, and, although I cannot claim to have gone into it thoroughly and systematically, and consequently must submit what I have to say with diffidence, it has occurred to me that perhaps one of the causes of the difficulty of coming to a practical agreement as to the best course of study for a young man wishing to become an engineer, as has been done for those preparing themselves for the church, the bar or medicine, is the fact that the field covered by the professions and pursuits now included by the term engineering, has become too great for any single course of study to be applicable to it. In every state in the Union there is practically a well-defined course of study which must be followed by those who intend to become members of the bar, and an examination which at least claims to be similar in character that each person must pass before he is admitted. There is little or no discussion as to whether some other system of education would be better. There are, of course, differences of opinion, as to the greater or less importance of some of the details of the students' work, but they are not such as attract any great attention. So with the church: each denomination has its own views as to the mental character of the candidates and as to the manner in which they should be instructed; but, practically, each sect is agreed as to the general principle upon which the studies of those who intend to enter the ministry should be conducted; so, in medicine, there is very little divergence of opinion as to the relation that the practical work in the dissecting room, at the clinic and in the hospital should bear to the theoretical training of the lecture-room and the text-books. There are, of course, some changes in the methods of theoretical instruction in which the more advanced schools have not been followed by the more conservative institutions, but they are rather questions of detail than of principle. They all agree as to the relation and character of the practical to the theoretical work and as to the time in which the former should be done. But, when we come to the training of the engineer, this general unanimity of opinion is no longer to be found. Is it because the study of engineering is of so recent a date that it has not had time to develop properly? This may be one reason, but it does not seem to me to be sufficient to account for the fact. The more I think of it the more it seems to me that the great difficulty

is that the field now attempted to be covered by an engineering education is too vast to come within any one system of instruction. The state of affairs is, to a certain extent, similar to what would be the case if a number of clergymen, doctors and lawyers should endeavor to lay out a course of study for students to follow in common with success and profit when a part of them (it would be impossible to determine beforehand which) were to devote themselves afterwards to the practice of the law, part to the practice of medicine and part to the work of the church. Now, while such a plan would never be proposed, yet I feel satisfied that, if several thousand students were compelled to follow a course laid out in this way, there would always be among them a few, whose special aptitude for one or other of the professions would be so great that they would rise to eminence in their own specialty; for they would assimilate and profit in the highest degree by that portion of the instruction peculiarly suited to their turn of mind. Yet there is no doubt that a great part of the time and energy of the mass of the students would be wasted, and that the useful effect of their training, as a whole, would be very discouraging.

No one would, of course, suggest or consider such a plan, but a reference to it may be of use in enabling me to impress more strongly upon your attention the idea which has suggested itself to me, and which, I think, may possibly be worthy of the attention of those who are giving the subject of technical education the advantage of their experience, their training and their thought; and I know that there are many in this Association to whom this is a subject of deep interest.

One of the most important duties, one of the greatest privileges of an educated, trained, thinking man is that of preventing waste, whether it be of matter or force, whether the latter be physical or mental; and what more dreadful waste can there be than the misdirected energies of the young student who has so little time at his disposal and so much to learn before he is obliged to enter upon these active duties by which he must gain his daily bread. If he who makes two blades of grass grow where one grew before deserves well of mankind, how much more he who aids in preventing the useless labor of sowing seeds that are likely to develop into worse than useless weeds!

If, as it seems probable, engineering is now becoming really

three professions or callings, differing so widely from one another as to demand a special training for each, is it not perhaps possible that no one collegiate course will be suitable and advisable for all? Is not the question, at least, worthy of thought and discussion? In the hope that you will deem it so, I submit it to you for your consideration.

PAPERS READ.

NICARAGUAN WOODS. By Prof. R. H. THURSTON, Ithaca, N. Y.

[ABSTRACT.]

THE paper contained an account of an investigation of the strength and other valuable qualities of the woods of Nicaragua made under the direction of the writer in the laboratory of the Sibley College of Cornell University. It was of the same character and scope as that on the Cuban Woods presented three or four years ago and published in full in Van Nostrand's Magazine. It is hoped that the paper may be of service in making known to our people the value of the timber trees of Central America as was the former in calling attention to those of Cuba. [Published in full in Journal Franklin Institute, 1887.]

THE AMERICAN SYSTEM OF WATER PURIFICATION. By Dr. ALBERT R. LEEDS, Hoboken, N. J.

[ABSTRACT.]

THE American system of water-purification is founded upon the three following novel and original processes:—

1. Artificial aeration under pressure.
2. Assisted precipitation by coagulants.
3. Mechanical filtration under pressure.

1. *Artificial aeration under pressure.* This process grew out of an investigation, which I was requested to make, into the causes of the very offensive taste and odor of that part of the water-supply of Philadelphia, during the months of January and February, 1883, which was derived from the river Schuylkill. I found that the Schuylkill was covered with ice throughout its entire length, and that the disgusting taste was due to the putrefactive decomposition of sewage thrown into the Schuylkill from the factories and sewers of Manayunk, a large manufacturing town located on this river six miles above the intake of the Fairmount pumping-station. In the course of the decay of this sewage out of contact with air, the oxygen gas, normally present in all sweet water, had been largely used up. On driving oxygen into the water I found that I could artificially oxidize fifty per cent of the readily putrescible organic matters

in solution. This result led to the appropriation by the city of Philadelphia of ten thousand dollars to purchase air compressors, which were attached to the ascending mains at the pumping-stations, and air was driven into the water under the corresponding great pressures. Shortly afterwards, the same process was applied to the water pumped at New Milford on the Hackensack river, the mixture of air and water being driven through a main seventeen miles in length, until it is delivered, at a height of 180 feet, into the receiving reservoir above Hoboken. This last plant has been steadily in operation for three years, and has resulted in accomplishing the purpose for which it was intended in this instance — *the prevention of the growth of algæ in the water-supply.* It has now gone into use at Champaign, Ill., Greenwood Park, Brooklyn, Somerville, N. J., and in many other towns.

2. *Assisted precipitation by coagulants.* This process is requisite when the suspended dirt is too finely divided to be arrested by the pores of the filter. Or, 2nd, when the water is colored by peaty extract, dye-stains, vegetable extracts, etc. 3rd. When it is foul and dangerous from the presence of sewage and the various pathogenic bacteria. 4th. When it is hard from dissolved carbonates and sulphates of lime and magnesia. In the first three cases, the coagulation is best effected by alum, from one-half to one grain of alum being ordinarily sufficient. In case peat is present, the alumina acts precisely like a mordant, uniting with the coloring matter as a reddish-brown lake, both the alumina in the form of a basic sulphate and the peat being thrown out of solution. If peat extract or some similar body is not present in the water, then I have proposed the employment of ferric chloride together with lime water, the coagulum of ferric hydrate carrying down with it all the bacteria present in the water. Waters which have temporary hardness are softened by the use of the required amount of lime, and those which are permanently hard are softened by the use of carbonate of soda, the water in the latter case being raised to the boiling point. In all these four cases, the precipitated silt, or peat, or ferric hydrate, or carbonate of lime, is and must be, removed by the final process of filtration.

3. *Mechanical filtration under pressure.* The universal practice in England is to purify the water by large filter-beds constructed of expensive masonry. The filtering itself is effected by two feet of sand, and the elaborate construction of graded gravel and broken stone beneath the sand is to provide channels to drain the filtered water away. In the American system the filters are made of iron tanks so strongly built as to withstand great pressure. The filtering is done by four feet of sand in these tanks. The cleansing of the filter bed, which in England is carried out by men shovelling off the dirt, is done in these tanks by reversing the current and sending the water up through a series of perforated pipes placed a foot below the surface. The water is drained away by a lower series of pipes, the pipes being double, one inside the other, both perforated, the space between them being filled with quartz gravel. A filter of this description, ten feet in diameter, filters one-quarter million gallons per diem.

A NEW METHOD OF FINDING AN EQUIVALENT UNIFORM LOAD PRODUCING BENDING MOMENTS APPROXIMATELY EQUAL TO THE MAXIMUM MOMENTS UNDER A MOVING TRAIN. By Prof. H. T. EDDY, Cincinnati, O.

[ABSTRACT.]

THE author first develops a new graphical method of exactly representing the maximum bending moments in a girder due to a set of wheels which move from end to end of the girder. These bending moments are represented as the difference of the ordinates of two equilibrium polygons of which one is a parabola.

The approximation in view consists in assuming the other equilibrium polygon to be a parabola also, as in fact it is nearly when the number of wheels in the set on the girder is large.

The maximum moments are then taken to be produced by a train consisting of one or more engines preceded and followed by a uniform train. Of this loading the engine excess only is taken to constitute the moving load.

The approximate formula for the equivalent uniform load is then

$$w = w_1 + \frac{2E}{l}\left(1 - \frac{l'}{2l}\right).$$

w_1 = weight per foot of uniform train.
E = total engine excess.
l = length of girder.
l' = total length of wheel base of engines.

ON THE DEFLECTION OF GIRDERS AND TRUSSES. By Prof. H. T. EDDY, Cincinnati, Ohio.

[ABSTRACT.]

IN this paper are defined the fundamental formulæ which express the deflections in terms of the stresses; and in case of the single intersection truss, the deflection due to both chord and web members is included.

A useful graphical system of constructing the deflections is developed in connection with these expressions, of such a nature that the deflection at any point of any member of the truss is readily determined.

REACTION POLYGONS AND THEIR PROPERTIES. By Prof. H. T. EDDY, Cincinnati, Ohio.

[ABSTRACT.]

THIS is a new general class of graphical polygons suitable for determining those positions of wheel weights in a moving train which produce the maxima bending moments and maxima shearing stresses at any points of a simple girder or of a single intersection truss.

The paper contains the general explanation of reaction polygons, the method of constructing them and their application in the graphical discussion of the following problems:

1. Determination of centres of gravity.
2. Determination of load at a panel point and the shear in girder, stringer and truss.
3. Determination of the segments of the girder and truss in which the maximum shear is dominated by the successive wheels.
4. Determination of the positions of an unlimited train which produce maxima bending moments at any given point of the girder and maxima stresses in the members of the unloaded chord of a single intersection truss. Comparison of any two moments at a given point of the span due to two different train positions.
5. Determination as in No. 4 of train positions for maxima stresses in loaded chord. Comparison as in No. 4 for loaded chord.
6. Most general comparison of the bending moment at one point of span and one train position with that at another point and a different train position.
7. Determination of points of maximum moment for each of a set of wheels all of which remain on the span. Determination of the wheel which produces the greatest maximum moment and the point of the span where it does this. Determination of the segments of the span in which the maximum moment is dominated by the successive wheels.
8. Same determinations, as in No. 7, in case where a uniformly distributed load covers the span in addition to the train of wheel weights.

ON AN IMPROVED METHOD FOR TESTING METALS. By Prof. CHARLES E. MUNROE, U. S. N., Torpedo Station, Newport, R. I.

[ABSTRACT.]

THE method consists in detonating gun cotton in contact with or near to the metal to be tested. The test may be applied to the original ingot from which the part is to be shaped, and serves to show the capacity of the metal to resist shocks, and also exposes the structure of the metal. It is deemed especially applicable to the testing of metals for guns.

EFFECT UPON THE STRENGTH OF IRON BY BEING SUBJECTED TO A PULL WHILE UNDER A TENSILE STRESS. By Prof. DE VOLSON WOOD, Hoboken, N. J.

[ABSTRACT.]

TWELVE specimens were prepared exactly alike. Two were broken without treatment, showing an average strength of 50,500 pounds per square inch. Six were put in the machine while at a dull red heat and

subjected to a steady pull of one-fifth the above stress, and four more to one-fourth that stress, for fifteen minutes; after which all were broken. Only three fell below 50,000 pounds, and those elongated 6 per cent or more while hot, and broke with over 47,000 pounds per square inch.

RANKINE'S SOLUTION OF THE PROBLEM OF THE TURBINE. By Prof. DE VOLSON WOOD, Hoboken, N. J.

[ABSTRACT.[1]]

THE solution of this problem given in "Prime Movers," is claimed by the author to be general for all turbines, but in reality it is for a special wheel, applicable only to the condition of maximum efficiency and not exact. I have, however, compared his formulas with exact ones and find, that in ordinary cases, it is correct within one per cent.

DOWNWARD DRAFT DEVICE FOR A FURNACE. By Prof. DE VOLSON WOOD, Hoboken, N. J.

NATIONAL ARMAMENT. By JAS. R. HASKELL, New York, N. Y.

[This paper will be printed in full by the author. Copies can be had free by addressing Mr. Haskell, 120 Broadway, New York.]

FRICTION OF ENGINES. By Prof. R. H. THURSTON, Ithaca, N. Y.

[ABSTRACT.]

THIS paper consisted of memoranda relating to the friction of engines as affected by their loads, and was a continuation of work reported upon at previous meetings of the Association.

A NEW HIGH-SPEED STEAM ENGINE INDICATOR. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

SOME three or four years since, in talking with Professor Sweet about an indicator for high-speed engines, he suggested having a small chamber connected with the cylinder by means of a stop-cock, the repeated sudden automatic opening and closing of which at a definite, adjustable part of the stroke should admit to the chamber steam of the pressure then

[1] To be published in Journal of Franklin Institute.

existing in the cylinder, which pressure could be indicated and registered by a gauge connected with the former. There seemed to me, however, to be difficulties in the way of obtaining accurate results by this method, and I mention it in presenting the new indicator which I have devised, only because of the similarity in principle involved in both. In the indicator which I exhibited to this Section at Montreal, the piston had its motion limited to a very small portion of the range of the spring, such portion, however, being automatically adjusted successively to all points in the range. In this indicator, in common with Professor Sweet's, the piston has its motion limited to a small portion of the time occupied by the stroke of the engine, such portion, however, being adjustable to all points of the stroke. In the earlier indicator the limitation was, therefore, one of space, and the piston was free to move its small distance at any time when the necessary change of pressure occurred; in this indicator the limitation is one of time, and the piston is free to move for a short period only, during which, however, it is free to move throughout the whole stroke, equivalent to the whole range of the spring.

The indicator consists of a plunger piston *A*, furnished with springs *B* and an indicating point or pencil *C*, which together correspond almost exactly with the original indicator without multiplying levers. The piston, however, is clamped by the piece *D* which is pressed against it by the spring *E* and pin *F*, so that it is free to move only when this clamp is released. For this purpose there is the lever *G*, link-bolt *H* and lever *I*, the roller on which is engaged by the cam *J* at a particular time during the revolution of the pulley *K*. The pulley is connected with the cross-head by some positive (generally reducing) motion, so that the levers are operated, and the clamp momentarily released at a definite point in the stroke. The drum *L* does not partake of the motion of the cross-head, but is controlled by the wooden hand-wheel *M*. The lever *I* is shown in the drawing in the plane of the paper, but by revolving *L* it is placed successively at all angles, *i. e.*, in any plane passing through the axis of *L*, *I* being mounted upon *L*; in this way as the paper on the drum is revolved under the pointer, the release of the piston is made to occur at the corresponding portion of the stroke. The drum may be moved slowly and continuously, and a pencil may be used to draw the card, but for more accurate work a point is used which scarcely touches the paper, and the drum may be allowed to remain stationary until the piston is seen to settle to its place, when the point may be pressed into the paper, and the drum revolved to a new place; in this way extra care may be taken to get accurately special portions of the card. It is evident that with high-speed engines, for which the indicator is designed, the clamp will be released at the same point of several successive strokes if the drum be moved in a discontinuous manner and at nearly the same point where its motion is continuous, and that the pressure at any point of the stroke may be obtained with any degree of accuracy by allowing a sufficient number of strokes before the drum is moved. By a simple device, *N*, *O*, the release is made to occur at will during the forward or backward stroke; otherwise, the pressure shown would be the average of the steam and back pressures.

ON THE UNIFORMITY OF PLANIMETER MEASUREMENTS. By Prof. T. C. MENDENHALL and JOHN MACK, Terre Haute, Ind.

[ABSTRACT.]

SEVERAL series of planimeter measurements of diagrams of the steam indicator, showed that the range of the results when the readings were by the same and by different individuals was not greater than one per cent of the whole.

AN ANALYSIS OF DYNAMO DESIGN. By FRANK C. WAGNER, Lynn, Mass.

[ABSTRACT.]

MOST of the writers upon the theory of dynamo design leave an undetermined factor in their formulæ. This factor, which is the ratio of the magnetic induction through the armature coils to the magnetizing force of the field magnets, is commonly determined by experiment. In the following it will be shown how this factor may be calculated from the form and dimensions of the iron parts of a dynamo.

In the ordinary formula for dynamos, $E = 4\, N n\, H$, H is the magnetic induction. The magnetizing force, M, equals $4\, \pi\, n'\, C$, where $n'\, C$ is the number of current-terms in the field magnets. Our problem is, M being given, to determine H.

In Maxwell's "Electricity and Magnetism" Vol. II, Art. 428, we read :— "The magnetic induction is a quantity of the nature of a flux, and satisfies the same conditions of continuity as the electric current does."

"In isotropic media the magnetic induction depends on the magnetic force in a manner which exactly corresponds with that in which the electric current depends on the electromotive force."

Now if we wind a soft iron ring with a number of turns of wire, and send a current through the wire, the magnetic induction may be said to pass through an isotropic medium; it may therefore be calculated from the impressed magnetic — or magnetizing — force and the magnetic resistance of the magnetic circuit. This magnetic resistance is found from the length and cross section of the iron, its specific magnetic resistance being known, in exactly the same way as is electrical resistance. Let us cut a small piece out of our iron ring. The magnetic resistance of the circuit is now made up of two terms, the resistance of the iron, and that of the air space. This may be calculated in the same way as the electrical resistance of a circuit composed of metals of different conductivities, *provided* that the air resistance is not too great in comparison with the resistance of the iron portion of the circuit. The magnetic resistance will then be made up of terms like $\frac{l}{\mu A}$; where l is the length of the body parallel to the

lines of magnetic induction, μ is the cöefficient of permeability, and A is the cross section perpendicular to the lines of force.

In a well constructed dynamo the air resistance should be of the same order of magnitude as the magnetic resistance of the iron portion. Hence this simple method may be applied to determine the magnetic induction in dynamos when we know the form and dimensions of the iron parts and the magnetizing force of the field coils. The writer has applied this method to two dynamos differing widely in construction, and has obtained a very satisfactory agreement with experimental results.

ON THE THEORIES OF THE LATERAL PRESSURE OF SAND AGAINST RETAINING WALLS. By Prof. MANSFIELD MERRIMAN, Lehigh University, Bethlehem, Pa.

[ABSTRACT.[1]]

THE paper points out the assumptions or hypotheses upon which the various formulas for the lateral pressure of earth are based. These hypotheses are in most cases shown to be arbitrary, and to lead to incorrect formulas except in a few limiting simple cases. It is claimed that no existing theory gives results which are correct for all cases, and that the defects of all methods lie in the assumptions. The point of departure for an exact theory seems to be a definition which shall include the physical properties of sand in regard to the direction of its pressure. This definition, having been established by experiment, will then take the place of the arbitrary hypothesis now employed.

ERROR OF APPROXIMATE CALCULATIONS OF THE EFFECT OF THE INERTIA OF THE MOVING PARTS OF A STEAM ENGINE. By D. S. JACOBUS, M. E. Instructor in Experimental Mechanics, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

THE forces given below are obtained by considering the moving parts as free bodies in space and calculating the forces required to produce the acceleration experienced. By employing this method all the forces re-

[1] The paper is published in full in the Columbia School of Mines Quarterly for October, 1887.

quired to produce the motion are included in the analysis and an exact solution of the problem obtained, whatever the shape of the connecting rod may be, provided its centre of gravity is on the line joining the centre of the crank and cross head pins.

The forces required to produce acceleration are

$$F = M\tau^2 R\,(\cos\theta + Z).$$

$$Y_1 = -m\tau^2 R \left\{ \frac{nl - l^2 - K^2}{n^2} \right\} \sin\theta.$$

$$Y_2 = -m\tau^2 R \left\{ \frac{l^2 + K^2}{n^2} \right\} \sin\theta.$$

$$P_1 = m\tau^2 R \left\{ \frac{n-l}{n} \cos\theta + \frac{(n-l)^2 + K^2}{n^2} Z \right\}$$

$$P_2 = m\tau^2 R \left\{ \frac{l}{n} \cos\theta + \frac{ln - l^2 - K^2}{n^2} Z \right\}$$

In which

F = force required to produce acceleration of piston, piston rod and cross head.

Y_1 = vertical component of accelerating force at cross-head end of connecting rod.

Y_2 = vertical component of accelerating force at crank-pin end of connecting rod.

P_1 = horizontal component of accelerating force at cross-head end of connecting rod.

P_2 = horizontal component of accelerating force at crank-pin end of connecting rod.

M = mass of piston, piston rod and cross head.

m = mass of connecting rod.

τ = angular velocity of crank.

R = radius of crank.

nR = length of connecting rod.

lR = distance from cross-head end of connecting rod to its centre of gravity.

KR = principal radius of gyration.

θ = crank angle.

$$Z = \frac{n^2\cos^2\theta - n^2\sin^2\theta + \sin^4\theta}{(n^2 - \sin^2\theta)^{\frac{3}{2}}}$$

The above equations are subject to the following conditions.

1. That the crank maintains a uniform angular velocity.

2. That the cross-head pin and crank shaft are on the centre line of the piston produced.

3. That the centre of gravity of the connecting rod is on a line passing through the centres of the cross head and crank pins.

The equations given have been deduced by three methods, each being used as a check upon the others, viz.:—

1. By conceiving the mass of the rod divided into two equal masses,

concentrated at distances equal to the principal radius of gyration on either side of the centre of gravity and determining the forces necessary to produce the required movement of the rod without separating the rotative from the translative forces.

2. By considering the entire mass of rod concentrated at centre of gravity of latter to determine translative forces and then combining the result with the couple required to produce rotation of rod considered as a compound body about centre of gravity.

3. By combining translative and rotative forces determined under assumption that connecting rod rotates about the wrist-pin.[1]

These equations become identical with those given by Prof. S. W. Robinson in his article on Counterbalancing of Engines, Trans. A. S. of Mech. Eng., 1881, and by Prof. Marks as reported in Journal of Franklin Institute, 1879, if the special assumptions are made that these writers have introduced regarding distribution of weights and simplicity of form. The equations herein offered may be applied to any shape of rod or any distribution of weight beyond the crank and wrist pin by determining radius of gyration of the rod.

In the first practical case considered herein the radius of gyration was determined both by experiment and by calculation. The method of calculating by measurements consisted in considering the rod to be divided into sections at right angles to its centre line, finding weight of each of these sections, centre of gravity of the whole rod and finally the radius of gyration. Forty-five sections were taken in the rod. The results obtained by experiment and by calculation are as follows:—

	By exp't.	Calcu'd.
Distance of centre of gravity from cross head pin, . .	23.12″	23.09″
Principal radius of gyration	15.0″	14.09″

The figures show that the radius of gyration can be obtained with abundant accuracy from calculations based upon a limited number of measurements of the rod or from a drawing of the same. Therefore for the second and third practical cases to which these formulæ are applied, the results of which are given below, the radius of gyration was calculated from dimensions obtained from drawings of the rods, the sections being taken in a similar manner to that employed in the first case just described.

The three cases to which the equations are applied are representative of the three practical types of engines in most common use, viz.:—

1. High speed engine of small power, New York Safety Steam Power Co's Horizontal Engine, 10″ × 12″. 300 revolutions per minute.

2. Locomotive Passenger Engine, Class P, Pa. R. R. Co. Revolutions taken at 250 per minute.

[1] The first and second of these methods are considered the most satisfactory, as by them centrifugal force, due to rotation of rod, is eliminated and the simplest analysis hereby obtained. The third method is that followed by Mr. F. E. Jackson, Journ. Frank. Inst., Sept. 1886, to determine some of the forces given herein.

3. Slow speed Engine, Corliss Engine, $26\frac{1}{8}'' \times 60''$. 60 revolutions per minute.

The results are contrasted in the accompanying table with figures obtained by the approximate methods set forth in the admirable treatise of C. T. Porter on this subject in which the lateral accelerating forces of the connecting rod are entirely neglected.

Class of Engine.	Revolutions per minute.	Maximum Pressure on Crank Pin. 1 Exact.	2 Approximate.	3 Difference.	$\frac{\Delta E}{\int pds}$. 4 Exact.	5 Approximate.	6 Difference.
Horizontal $10'' \times 12''$	300	58.1	57.2	1.5%	.188	.176	6.3%
Locomotive $18\frac{1}{4}'' \times 24''$	250	54.7	53.6	2.0%	.158	.150	5.1%
Corliss $26\frac{1}{8}'' \times 60''$	60	76.1	75.2	1.2%	.145	.136	6.2%

Columns 1 and 2 contain values of maximum pressure to which the crank pin is subjected in pounds per square inch of piston area. Columns 4 and 5 contain the ratio of the periodical excess or deficiency of energy to the whole energy exerted per revolution which is equivalent to $\frac{\Delta E}{\int pds}$ in Rankine's equations for size of fly wheels.[2]

Indicator cards of the engine were used in order to obtain pressure of steam on the piston.

An inspection of the difference given in columns 3 and 6 will show that for obtaining the ratio $\frac{\Delta E}{\int pds}$ and the maximum pressure on crank pin, Porter's method will give as accurate results as are required for any practical use. If, however, the proper size of counterweight is to be determined, the exact formulæ may be required. It is the purpose of the writer to discuss the counterweight in a succeeding paper.

Mechanical inspections of railway tracks and results obtained.

By P. H. Dudley, New York, N. Y.

[abstract.]

The diagrams of mechanical inspections of railway tracks to be of much value must be taken with instruments giving positive results, which can be repeated at stated intervals for comparisons. Studying such diagrams of various railroad tracks, it was ascertained that the rails had quite defi-

[2] Rankine's Steam Engine, page 60.

nite forms of permanent set in regard to their vertical bends, which until recently could be classified under three principal primary forms, viz.: The first, second and third. The first form includes those rails low at the joints and high in the centre. The second form, those rails low at the joints and centre but high at the quarters. The third form includes those rails having a series of short irregular bends. The first and second forms are acquired in service, though the higher standard of track maintained, the less the permanent set and cost of transportation.

On trunk lines, the track in best condition, the second form of permanent set predominating, the cost per ton mile for freight is about four mills, but on a line where the first form predominates, the cost is over five mills. The third form is principally due to want of care in manufacture and finish of the rails, at the mills. The difficulties of rolling increase with the weight and section of the present heavy rails. So far, the experience with them is that the loss of metal per ton, passing over them, is greater than with the light rails, but the cutting of the ties reduced, and the safety and stability of the track increased. Connected with the mechanism for taking diagrams, is an apparatus for ejecting paint on the rails, when deflections occur, showing the trackmen where to surface the rails.

This has proven of so much benefit, that several roads have been able to reduce the deflection in heavy rails to less than one-eighth of an inch in eleven feet of the rails. In tracks where such a high standard is maintained, the rails of good steel do not cut out or wear at the ends but little if any faster than on the entire length of the rail. This is an important matter, for under a lower standard of track, many of the rails have been so badly cut out at the receiving ends as to require taking up from the track, sawing off the ends, redrilling and relaying, before they could be brought up to a fair surface. The indications at present are that rails, having a good surface when new, can be maintained in nearly uniform surface their entire length, for many years. With the increased wheel load cars and locomotives the section of the rail must be made stiffer and the weight of the rail increased. To insure proper wear the width of the heads of the rails must be increased.

An improved arrangement of Siemens' platinum pyrometer for measurement of high temperatures by the variation of electrical resistance. By J. E. Denton, Stevens Institute, Hoboken, New Jersey.

[ABSTRACT.]

The paper explains an arrangement of Siemens' platinum pyrometer in which the wires, leading from a galvanometer to the small platinum wire whose resistance is to be measured, are protected by the circulation

of water in an enveloping tube of iron, thus permitting the apparatus to remain subjected to high temperatures for any desired length of time. The apparatus provides a means whereby a shield of asbestos can be used to eliminate the effect of direct radiation from the fuel, thereby enabling the heating effect of the gaseous products of combustion to be determined separately. Attention is called to the fact that recent investigations to determine the relation between the temperature and electrical resistance of platinum, by Mr. Callender of Cambridge University, England (Proceedings Roy. Soc., 1886) confirm the formula given by Siemens in his original memoirs upon the subject. [For full paper see "Electrical World."]

ON THE THEORETICAL EFFECT OF ERRORS OF OBSERVATION IN CALORIMETER FOR DETERMINING THE LATENT HEAT OF STEAM. By J. E. DENTON, Stevens Institute, Hoboken, N. J.

[ABSTRACT.[1]]

THE paper presents the results of simultaneous measurements of the total heat of steam, with an open barrel calorimeter and condensing worm calorimeter, respectively, showing thereby that successive determinations with the former instrument differed far more widely from each other than was the case with the condensing worm. A theoretical discussion and calculation of the maximum and probable errors of each instrument showed that this irregular behavior on the part of the barrel could not be attributed to observational error. The hypothesis was therefore advanced that the steam rushing into the barrel sometimes parted with its heat by bubbles of vapor rising in a finely divided state to the surface of the condensing water, and giving off latent heat to the atmosphere, the agitation of the water causing such action to escape the attention of visual observation.

Regnault's apparatus for determining the latent heat of steam, whose results are universally used as a standard, was exhibited by diagram and its theoretical error shown to be less than any form of calorimeter used in practice. The use of a condensing worm form of calorimeter was urged as the only reliable form of apparatus and the continuous form of instrument as designed by Mr. C. H. Barrus was recommended as the best yet proposed.

[1] For full paper see "American Engineer."

RESULTS OF DUPLICATE TESTS with

OPEN BARREL CALORIMETER connected on same supply pipe with ORDINARY SURFACE CONDENSER.

TIME.	W pounds.	w pounds	TEMPERATURES. Fahrenheit.			p gauge lbs. per □ in.	Per cent of PRIMING.	Per cent of PRIMING.	p gauge lbs. per □ in.	TEMPERATURES. Fahrenheit.			w pounds	W pounds	TIME.
			$t_2°$	$t_1°$	$t_3°$					$t_3°$	$t_1°$	$t_2°$			
8.12	242.25	34.75	125.5	37.	—	48	+50%	—	—	—	—	—	—	—	8.12
8.35	242.25	22.75	136.75	38.5	—	45	+ 7%	3.8 %	45	102.5	50.25	123.75	5.297	75.—	8.35
9.02	242.25	19.50	120.5	39.75	—	54¾	+ 9%	2.75	54¾	100.5	39.75	119.	5.625	77.—	9.02
9.45	242.25	12.25	117.0	39.75	—	56	—48%	2.54	56	100.75	40.75	119.	5.544	76½	9.45
10.00	—	—	—	—	—	—	—	2.48	54½	97.	39.75	119.75	5.504	75	10.00
10.30	250.25	20.25	128.5	38.25	—	53½	—4 3	1.72	53½	98.	39.75	120.3	5.638	74.78	10.30
11.00	250.25	17.25	116.25	39.25	—	55	—3.—	—2.35	55	101.25	38.75	120.25	5.514	75.	11.00
11.30	250.25	19.25	114.75	39.25	—	52.5	+12	1.00	52.5	100.25	38.25	117.75	5.563	75.	11.20

RESULTS OF DUPLICATE TESTS with

REGNAULT'S APPARATUS — J. C. HOADLEY'S APPARATUS.

TIME.	W pounds.	w pounds	TEMPERATURES Fahrenheit.			p absolute lbs. per □ in.	Per cent of PRIMING.	Per cent of PRIMING.	p absolute lbs. per □ in.	TEMPERATURES Fahrenheit.			w pounds	W pounds	TIME.
			$t_2°$	$t_1°$	$t_3°$					$t_3°$	$t_1°$	$t_2°$			
—	146.697	2.61	61.18	37.42	—	56.32	0.46%	0.58%	68.9	—	44.88	94.4	9.7	217	—
—	146.69	2.98	63.82	40.73	—	57.17	0.34	1.72	90.2	—	38.45	102.62	12.7	"	—
—	146.69	2.06	72.21	51.6	—	62.34		1.75	65.8	—	38.0	77.65	7.83	"	—
—	146.679	2.86	74.41	52.29	—	66.49	0.11	0.53	51.3	—	43.63	93.07	9.68	"	—
—	146.706	2 95	61.16	38.16	—	78.42	0 38	0.28	79.7	—	35.48	86.2	9.75	"	—
—	146.679	3.09	64.42	40.57	—	78.67	0.80	1.38	82.5	—	40.05	88.43	9.5	"	—
—	146.696	3.00	61.11	37.69	—	81.13	0.16	0.44	89.7	—	41.95	91.8	9.84	"	—
—	146.697	3.29	63.00	37.47	—	84.14	0.09	1.16	35.6	—	41.65	104.	12.64	"	—

JOINT SESSION OF SECTIONS D AND I.

THE QUESTION OF ISTHMIAN TRANSIT. By Commander H. C. TAYLOR, U. S. Navy, Poughkeepsie, N. Y.

[ABSTRACT.[1]]

REFERENCE to the three routes considered, Nicaragua, Tehuantepec and Panama.

Brief description of Panama canal and its present condition; work done, debt incurred.

Proposed plan of ship railway across Tehuantepec, brief description.

Advantages of Nicaragua discussed.

Development of Central America.

Establishment of industries.

The international question.

Neutrality of the canal.

Possible aggression of powerful maritime nations.

The relation of the United States to the canal in the future.

THE ENGINEERING FEATURES OF THE NICARAGUA CANAL. By Civil Engineer R. E. PEARY, U. S. N., Washington, D. C.

[ABSTRACT.]

THE Nicaragua Canal is known by name, probably, to ninety-nine out of every hundred persons in this country; but the revised route, the enlarged capacity and the new features presented as the result of the last survey, made two years ago by the United States government expedition in charge of Civil Engineer Menocal, United States Navy, are not so well known and of them I will speak. The distance from ocean to ocean by the proposed route is 169.8 miles. Of this distance, however, only 40.3 miles are actual canal, the other 129.5 miles being free navigation through Lake Nicaragua, the Rio San Juan and the valley of the San Francisco. Beginning at the port of Brito on the Pacific side, the canal ascends the valley of the Rio Grande by four locks, and cutting through the low "divide" enters Lake Nicaragua 17.27 miles from Brito at an elevation of 110 feet above the sea. The route then extends across the lake, which is 40 miles wide and over 90 miles long, to its outlet into the Rio San Juan, a distance of 56½ miles. Then down the broad deep reaches of the majestic San Juan to the dam, 64 miles from the lake. This dam, 1,255 feet long and 52 feet high, backs the water of the river the entire distance to

[1] This and the three following papers will be printed in full and can be had from the authors.

the lake and makes it simply an extension of the lake. On the north bank of the river just above the dam a short section of canal, less than two miles long, cuts through the hills into the Y-shaped valley of the Rio San Francisco lying north of the San Juan and separated from it by a range of hills. An embankment 6,500 feet long and 51 feet high in the centre, built across the stem of the Y, floods this valley to the level of the water above the dam and makes about ten miles of lake navigation. At the eastern end of this lake commences the eastern division of this canal and pierces the "divide" by a cut 14,200 feet long and averaging 149 feet in depth. At the eastern end of this cut is the upper lock of the Atlantic flight. From here the canal descends the valley of the Deseado by three locks to the sea level and stretches across the lagoon region back of Greytown to the harbor eleven and one-half miles distant. From the last lock to Greytown, the same as at Brito on the west side, the canal is enlarged, forming an extension of the harbor eleven and one-half miles inland. The lake and river must form a part of any and every canal route through Nicaragua, and the location as a whole is the result of Civil Engineer Menocal's complete and exhaustive personal knowledge of the entire country from ocean to ocean, gained in the course of eight different surveys extending over a period of fifteen years and supplemented by a conscientious study of all that has been done by others in that region.

Of the 40.3 miles of actual canal, about twenty-seven miles will be excavation pure and simple, while the remaining thirteen miles will be largely if not entirely excavated by dredges. With the convenient dumping ground for earth excavated, with a large portion of the rock from the summit cut utilized close at hand in the construction of the locks, the dam across the Rio Grande, and in pitching the slopes of the canal, and a still larger quantity to be consumed in the construction of the breakwaters at Brito, the work in this section admits of the most economical execution. The "divide" cut from the basin of the San Francisco to the upper lock, 14,200 feet in length and with an average depth of 149 feet, is, it is admitted, a very serious job, but with the neighboring streams offering water at a high head for removing the surface earth by hydraulic mining, with a large plant of power drills worked by compressed air, from the same source, and the use of modern explosives to remove the rock, with a large proportion of the excavated rock to be used in the construction of the locks and the dam, and in pitching the slopes of the canal; and a still larger quantity utilized in the construction of the harbor at Greytown; with the laborers above the miasma and mosquitoes of the swamp and exposed to the pure breath of the "trades" the work can be done without serious difficulty.

There are two features of this project which to many who have not made such structures a study cause a question of safety to arise; one is the dam, which at one stroke gives us sixty-four miles of river navigation, and the other is the embankment, which at a second stroke gives us over eight miles of lake navigation and completely solves for that portion of the canal from the dam to the "divide" (thirteen miles) the important problem of

protection from surface drainage, but neither of them is anything more than "small potatoes" when compared with many others scattered about the world and serving much less important purposes than those under consideration, and beside the Quaker bridge dam they are pigmies. Right here at the Croton reservoir is a dam which is to-day standing twice the strain that either of them will ever be called upon to resist. The locks are magnificent structures of concrete 650 feet long, 80 feet wide, and 30 feet deep, capable of containing any merchant vessel afloat, except the *Great Eastern* and possibly the *City of Rome*. The necessary machinery for moving the locks and culvert gates, for hauling the ships in and out of the locks, for electric lights and other purposes will be worked by hydraulic power furnished by the locks themselves.

In regard to the general question of locks the late Colonel John C. Stevens, for many years president and chief engineer of the New Jersey Railroad and Canal Company, and justly regarded as the most eminent canal engineer in this country, said in an article published in the *American Engineer* of Jan. 30, 1885:

"Locks are absolute sources of safety. A sea-level canal being sunk below the level of the surrounding country thereby becomes a drain, and is necessarily subject to all the risks from water that such a location entails, however skilfully the plans may be designed and the earthworks constructed. Unknown and uncertain risks must be assumed and the chances taken thereon. The precise amount of these will vary, but under the best conditions they may be appreciable, while under those that are unfavorable they will be such as to seriously impair the value of the work as a reliable channel of trade. The adoption of the lock system raises the canal above the ordinary drainage, and thus materially lessens the dangers which arise from that insidious enemy, water; and if the canal is well located they can generally be entirely removed."

And the same distinguished Ashbel Welch, to whom Colonel Stevens refers, says: "An artificial strait, a water course without impediment and all such phrases have a magnificent ring, but to spend millions of dollars for an idea or to satisfy an unreasoning or an uninformed public opinion is bad engineering. That is the best engineering, not which makes the most splendid, or even the most perfect work, but that which makes a work that answers the purpose well at the least cost. The demand of the public for a canal without locks reminds one of Charles Lamb's youthful Chinaman, who for want of knowing any cheaper way burned down his house to roast his pig." Again, "as for accidents, there is less danger with suitable appliances than on any other 1,000 feet in the canal, for vessels are under more perfect control." Stephenson, the celebrated English engineer, says: "It is a curious fact illustrative of the strength of prejudice that when Whitworth proposed to form a lock at Leith in 1786 it met with strong opposition on the ground of its being dangerous to shipping." And he adds, "such an objection, it is almost needless to add, is never now heard of."

To-day not a vessel discharges at Liverpool or Havre that does not pass through the dock gates, which is equally or more difficult than entering a lock, and I could fill a page with a list of French and English ports at which every vessel must pass through two locks before she can reach the quay to discharge. Much has been said about the harbors at the termini of the Nicaragua route, but neither time nor space will permit me to enter into the discussion here. It may be said, however, that there is no practical route for a canal across the American Isthmus that has good harbors, and it is believed that those at the termini of the Nicaragua canal can be made first class at less cost than those of any other route. There is nothing more difficult in the improvement of Brito Harbor than has been successfully accomplished at numerous French and English breakwater protected ports and harbors, and the maintenance of the harbor of Greytown will be a much less serious job than is the maintenance of the Port Said entrance of Suez, with the enormous silt discharge of the Nile driven across its mouth by strong littoral currents.

Lake Nicaragua has a surface area of some 2,000 square miles and a drainage area of not less than 8,000 square miles, and the Rio San Juan, its only outlet, discharges at its lowest stage, near the close of the dry season, eight times the maximum supply required by the locks. An inexhaustible supply of the best building material, such as lime, natural cement, stone and timber, can be obtained on the line of the canal, and with an abundance of palm leaves for thatching, such temporary buildings as are required for the accommodation of the working force and the protection of property can be constructed at little more expense than that of handling the material.

At Suez the traffic has been seriously delayed by the dimensions of the canal and the inadequate number of the turnouts. In the present project, not only have enlarged prisms been provided for, but large basins are proposed at the extremities of the locks. These basins, the enlargement of the canal at each end, with the lake, the river, and the San Francisco basin, will permit vessels to pass each other without delay at almost every point on the route. In 22.37 miles, or 57 per cent, of the canal in excavation the prism is large enough for vessels in transit to pass each other, and of a sectional area in excess of the maximum area in the Suez Canal; the remaining distance in which large vessels cannot conveniently pass each other is so divided that the longest is only 3.67 miles in length; that, with two exceptions, those short reaches of narrow canal are situated between the locks and can be traversed by any vessel in less time than is estimated for the passage of a lock; consequently, unless a double system of locks be constructed, nothing will be gained by an enlargement of the prisms. In the lake and in the largest portion of the San Juan River vessels can travel almost as fast as at sea. In some sections of the river, and possibly in the basin of the San Francisco, although the channel is at all points deep and of considerable width, the speed may be somewhat checked by reason of the curves.

ESTIMATED TIME OF THROUGH TRANSIT BY STEAMER.

	H.	M.
38.98 miles of canal, at 5 miles an hour	7	48
8.51 miles in the San Francisco basin, 7 miles an hour	1	14
64.54 miles in San Juan River, at 8 miles an hour	8	4
56.50 miles in the lake at 10 miles an hour	5	39
Time allowed for passing seven locks, at 45 minutes each	5	15
Allow for detention in narrow cuts, etc	2	00
Total time	30	00

The experience of the Suez Canal shows that the actual time of transit is more likely to fall under than to exceed the above estimate. The traffic of the canal is limited by the time required to pass a lock, and on the basis of forty-five minutes (above estimated), and allowing but one vessel to each lockage, the number of vessels that can pass through the canal in one day will be 32, or, in one year, 11,680, which, at the average net tonnage of vessels passing the Suez Canal, will give an annual traffic of 20,440,000 tons. This is on the basis that the navigation will not be stopped during the night. The estimate of the total cost of the canal is $64,043,699, which sum includes twenty-five per cent for surveys, hospitals, etc., and contingencies. The completion of the canal will require six years, one for final location and five for active work of construction, and the probable traffic for 1892, the possible date of completion of Nicaragua Canal, 6,506,214 tons.

If there is any lesson or meaning in the history of the past twenty years; if what has been is of the slightest value as a criterion of what will be, then in ten years or less after the completion of the Nicaragua Canal it will have to be double tracked; that is, the locks will have to be duplicated and some sections of the canal widened, and then its capacity will be unlimited. The lake, the river and the basin of the San Francisco can already pass the commerce of the world.

The canal route which I have had the honor to describe does not contain a doubtful or involved problem or one which has not been already solved by engineers. There is not a detail of the work which, if intelligently designed and properly constructed, will not be as free from danger as any work of human hands can be.

The features of the canal are bold, but they are bold without foolhardiness, bold with the confidence born of intimate knowledge of the country and the possession of engineering level-headedness. For centuries the exquisite, fragrant breath of the "trades" has swept across the lake, bearing whispers of its beauty over the narrow "divide" to the Pacific; for centuries the blue waves of the lake have heard the murmur of the Pacific surf and dashed themselves upon the shore in vain attempts to force the hand-breadth barrier. For centuries the crafts of men have toiled thousands of miles to gain a dozen; but to-day the impatient commerce of the world cries, "Rend the puny barrier and let me through," and our own imperial Orient and Occident-facing republic answers, "Rend the puny barriers and join my coasts in one unbroken stretch from Eastport to the Straits of Fuca."

CLIMATIC AND SANITARY NOTES ON THE NICARAGUA CANAL ROUTE. By Dr. JOHN F. BRANSFORD, U. S. N., Smithsonian Institution, Washington.

[ABSTRACT.]

THE backbone of the continent, leaving Costa Rica, runs northwest across the course of the trade wind. The section under consideration is the depression in the ridge between the mountains of Legovia, four thousand feet high, and the peaks of Costa Rica, over eleven thousand. The bottom of the depression is occupied by Lake Nicaragua and the Rio San Juan. The axis of the valley is nearly east and west, and, lying in the belt of the northeast trades, there is an almost constant breeze through this gap to the Pacific. This wind, in drying and ventilating the country and lowering temperature, is the great sanitary agent.

The temperature of Nicaragua, as shown by the records of Childs, Lull, Flint and the recorder at Granada, is very uniform. In the records of five years the maximum is 93°, and 65° the minimum.

The tropical cloud-belt, which follows the sun north, is late reaching Nicaragua. And the duration of the wet season is shorter and the rainfall less than in more southern sections of Central America. In the records used the greatest rainfall was 97.70 inches and 35.98 the lowest.

Fortunately, the work of cutting through the swamps of the eastern section will be done by machinery, requiring few white men to be exposed. The heavy cut coming next is through hills, affording excellent sites for camps. The neighborhood of the great dam has similar advantages. Wherever good camping ground is not convenient on the river, parties can sleep in flat boats anchored to get the wind over a stretch of water. Because of the immense surface of the lake, and the river receiving no considerable tributary above the mouth of the San Carlos, the upper San Juan is not subject to the sudden floods that leave conditions favorable for malaria. West of the lake the conditions are as favorable as in almost any country. The drainage is good; there is practically no rain for six months of the year, and the constant breeze at this season has lost its moisture on the Atlantic slope. The nights are cool, permitting refreshing sleep.

Drinking water is good along the whole route of the canal. The cultivated Pacific slope of Central America will furnish fresh provisions. From the pastures of Costa Rica, Chontales and Honduras good beef will be supplied, and everywhere fruit may be raised without limit. The abundant timber will make inexpensive houses and hospitals, which can be destroyed when desirable. The coöperation of the Nicaragua government will make practicable rigid discipline in camp police, quarantine, etc.

In the paper are an abstract of the medical journal of the surveying party and discussion of sites and sanitary arrangements for camps, hospitals, etc.

Notes on the history of Nicaragua, and the advantages of the lake to an isthmian canal, showing why the project should be begun at once. By J. W. Miller, Pier 36, N. R., New York, N. Y.

[ABSTRACT.]

I. A SHORT history of the various schemes for connecting the two oceans at Nicaragua, from the time of the early Spanish settlement to the present time.

II. Memoranda obtained by the author, while in Nicaragua, concerning the geographical fitness of the route; also notes on the lake and river as gained by personal observation.

III. Reason why the time is now ripe for the enterprise and the duty of the hour.

SECTION E.

GEOLOGY AND GEOGRAPHY.

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ADDRESS

BY

G. K. GILBERT,

VICE PRESIDENT, SECTION E.

THE WORK OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS.

ELEVEN years ago the Association met at Buffalo. It was the year of the Centennial Exhibition, and we were honored by the presence of a number of European geologists. This naturally opened the subject of the international relations of geology, and the proposition to institute a Congress of geologists of the world took form in the appointment by the Association of an International Committee. The project thus initiated found favor elsewhere, and there resulted an international organization, which up to the present time has held three meetings. It convened first at Paris in 1878, then at Bologna in 1881, and at Berlin in 1885. Its next meeting will be held in London next year, and an endeavor will be made to secure for the United States the honor of the fifth meeting. The original committee of the Association has been continued, with some change of membership, and has sent representatives to each session of the Congress.

The work of the Congress as originally conceived and as subsequently undertaken has for its scope geologic nomenclature and classification, and the conventions of geologic maps. The particular classifications attempted are the establishment of the major divisions used in historic and stratigraphic geology and the subdivision of volcanic rocks. In nomenclature three things are undertaken: first the determination of the names of historic and stratigraphic divisions; second the formulation of rules for nomenclature in paleontology and mineralogy; and third, the establishment and definition of the taxonomic terms of chronology (period, epoch,

etc.,) and of stratigraphy (system, series, etc.). The map conventions most discussed are colors, but all signs for the graphic indication of geologic data are considered. The Congress has also undertaken the preparation of a large map of Europe, to be printed in forty-nine sheets.

The work was for the most part planned at the Paris meeting, and committees were appointed to formulate subjects for action by the Congress at subsequent sessions. Briefly stated, the work accomplished to the present time is as follows: Agreement has been reached as to the rank and equivalence of the taxonomic terms employed in chronology and stratigraphy, a set of rules for paleontologic nomenclature has been adopted, and many sheets of the map of Europe have been prepared for the engraver. A partial classification of stratified rocks has been agreed to and also a partial scheme of map colors, but the reports of proceedings indicate that action in these matters is tentative rather than final.

It is understood that both of these subjects will have prominent place in the proceedings at the London meeting, and the American committee is endeavoring to prepare itself for representative action at that meeting by ascertaining the opinions of all American geologists on the various subjects. It has asked this Section to set apart a day for the discussion of some of the more important questions, and it can hardly be doubted that the Section will realize the mutual advantage of thus assigning the time requested. I am personally so impressed with the importance of the possible work of the Congress that I shall devote the present hour also to its consideration.

The first thing the Congress did was to select names for a set of categories to express the taxonomic rank of stratigraphic divisions, on the one hand, and of chronologic divisions on the other. In the terminology of zoölogy and botany the words kingdom, class, order, family, genus, species, etc., however difficult of definition they may severally be, nevertheless are used always in the same order of inclusion. No systematist in those sciences would think of grouping orders together and calling them a family, or of styling a group of families a genus. But in geology there is no such uniformity of usage. With some writers a group is larger than a series, with others it is smaller. With some an age includes several periods, with others a period includes several ages. There are even writers who ignore the distinction between stratigraphy and chronology;

and among the classifications submitted to the Congress is one in which an age is subdivided into systems. There is a manifest advantage in bringing order out of this chaos, and so great is the utility of uniformity and perspicuity that the decisions of the Congress in this regard will unquestionably be followed by future authors. The terms and the order adopted by the Congress are as follows: Of stratigraphic divisions that with the highest rank is *group*, then *system*, *series* and *stage*. The corresponding chronologic divisions are *era*, *period*, *epoch* and *age*. This order of rank is strange to most English readers and writers, and so is one of the terms — *stage* — but the strangeness is only a temporary disadvantage and will not seriously retard the adoption of the convention. The fact that we have previously used the words in a different sense, or that their etymology might warrant a different meaning, need not deter us, for we know from frequent experience that the connotations of a word transferred from one use to another quickly disappear from consciousness, leaving it purely denotative. The introduction of the word *stage*, which can hardly be said to have had an English status heretofore, or at least the introduction of some new word for that part of the column, was necessitated by the restriction of the word *formation* to a special meaning, — the designation of mineral masses with reference to their origin.

The same restriction vacated another office that had been filled by formation, and to this office no appointment was made. I refer to the use of the word to denote indefinitely an aggregate of strata —as in saying, This formation should be called a series rather than a system. This is an important function, for which some provision must be made. I suggest that we may advantageously enrich our language by the permanent adoption of *terrane*, a word whose English meaning has not been well established.

The fixation of the chronologic terms creates a similar difficulty. We have crystallized out of our magma the terms *era*, *period*, *epoch* and *age*, and there remain in the ground-mass only *eon*, *cycle* and *time*. Of these, *eon* has a poetic connotation which seems to unfit it for this particular use; *cycle* implies repetition or recurrence; and *time* has been so generally applied to unlimited duration that it is difficult to apply it also to limited duration, even though the nature of the limitation be indefinite. On the whole, *time* seems open to the least objection, but I cannot help regretting that either *period* or *age*, both of which have heretofore passed current

in the indefinite sense, was not reserved by the Congress for that function. With English-speaking peoples the word *eon* could have been better spared for the definite series.

But while the terms selected by the Congress are not beyond criticism, the benefits to be derived from an agreement in an orderly system are so great that I for one shall unhesitatingly adopt them as they stand,— provided, of course, that the Congress makes no effort to improve its selection. A small reform of this nature yields its profit to this as well as future generations, and I hold it a duty to favor even those reforms which involve so much effort and pains that their blessings cannot be realized by those who initiate them. Such are the exchange of our English spelling for a rational system, and the exchange of decimal notation in arithmetic for a binary notation. My application of the new nomenclature begins with this address, in the preparation of which I have experienced its utility. That you may have no difficulty in interpreting my reformed language, I have placed the taxonomic legend on the wall, with the addition of the complementary indefinite terms, terrane and time.

Terranes.	Times.
Group.	Era.
System.	Period.
Series.	Epoch.
Stage.	Age.

There are propositions before the Congress to distinguish the names of individual groups, systems, series and stages by means of terminations, those of the same rank having the same termination. Thus it is proposed by a committee that every name of a group shall end in *ary*,— Tertiary, Primary, Archeary; it is proposed that names of systems end in *ic*,— Cretacic, Carbonic, Siluric; it is proposed that names of series end in *ian*,— Eifelian, Laramian, Trentonian; and it is proposed that stage names terminate with *in*. Another committee suggests that *ic* be used for stages instead of systems. The adoption of such a plan would enable a writer or speaker to indicate the taxonomic rank of a terrane without adding a word for that purpose. If he regarded a certain terrane taking its name from Cambria as a system, he would call it the Cambric; if he esteemed it only a series, he would say Cambrian; and there would be no need of adding the word system, or series in order to express his full meaning. Conversely the reader or hearer would always learn its taxonomic rank, or supposed

rank, whenever a terrane was mentioned. These I conceive to be the advantages derivable from the change, but they would not be the only effects. It would become impossible for a geologist to name or allude to a terrane without declaring its rank, and the consequences of this would be evil in many ways. In the first place one could not discuss terranes from any point of view without expressing an opinion as to their taxonomy, and the change would thus contravene one of the most important rights of opinion — namely, the right to reserve opinion. Again, geologists who differed as to the rank of a terrane would necessarily terminate its title differently, and a needless synonymy would thus be introduced. In the third place the created necessity for taxonomic discrimination on all occasions would tend to direct undue attention to taxonomic problems. Taxonomy would be conceived by many geologists as an end instead of a means, just as correlation has been conceived, and energy would be wasted in taxonomic refinement and taxonomic controversy. It is convenient for purposes of description and comparison to classify the strata that constitute a local columnar section in phalanges of various magnitude or rank, but the criteria on which we depend for discrimination are in the nature of things variable and offer ground for endless difference of opinion; and it would be extremely unfortunate to have such differences perpetually brought to the foreground.

Another subject considered by the Congress is the nomenclature of paleontology. A committee appointed for the purpose formulated rules for the establishment of the names of genera and species, and their report was adopted by the Congress. I have no opinion to express as to the wisdom of the rules, but it is a matter of surprise that a body of geologists assumed to speak with authority on the subject. From one point of view paleontology is a part of geology; from another point of view it is a part of biology. In so far as it names genera and species it is purely biologic, and it would seem proper that the students of fossils unite with the students of living animals and living plants in the adoption of rules of nomenclature.

A similar remark applies to the nomenclature of mineralogy, in regard to which no action has yet been taken. The most intimate relations of systematic mineralogy are with chemistry.

Yet another projected work of the Congress is the classification of eruptive rocks. Up to the present time action has been deferred,

and it may reasonably be hoped that no scheme of classification will be adopted. If there existed a system of classification which gave general satisfaction and had stood the test of time, there would be little harm (and little or no advantage) in giving it the official stamp of approval. If the main features of a classification were well established and the residuary discrepancies were recognized as unessential, it is conceivable that some benefit might be derived from the submission of the matter to an assembly of specialists. But the actual case is far different. Not only is there wide difference as to the classification of volcanic rocks, but there is no agreement as to the fundamental principles on which their classification should be based, for we still lack an accepted theory of volcanism. At the same time observation is being pushed with great vigor, and with the aid of new and important methods. With the rapid growth of knowledge and ideas classifications are continually remodelled, and the best is in danger of becoming obsolete before it has been printed and circulated. Should the Congress enter the lists, one of two things would occur. Either its classification would be treated like that of an individual and ignored as soon as a better one was proposed, or it would be regarded as more authoritative, and new facts would for a time be warped into adjustment with it. In either case the reputation of the Congress would eventually suffer, and in one case science would suffer also.

There remain to consider the two most important undertakings of the Congress, the classification of terranes and the unification of map colors. The Congress is attacking these subjects indirectly by means of a third undertaking, the preparation of a geologic map of Europe, and this method of approach has had the effect of making it difficult properly to interpret its action. There can be no doubt that those who originally organized the work contemplated the enactment of a stratigraphic classification to be applied to the entire earth and the selection of a color scheme for use either in all geologic maps or in all general geologic maps. But at the Berlin session the committee in charge of work on the map of Europe pressed the Congress for the determination of questions on which hung the completion of the map, and many hasty decisions were reached, while not a few disputed points were referred to the map committee. The debates indicate that much or all of this work was provisional or of merely local application, but the resolutions adopted show little qualification. It should be added

that the official minutes of the meeting are still unpublished. In view of the uncertainty thus occasioned I shall not attempt to characterize the attitude of the Congress on the subject of classification, but shall merely develop my individual view.

It is the opinion of many who have discussed the general classification of terranes by convention of geologists that the smallest unit of such classification should be the stratigraphic system. What is a stratigraphic system? The Congress implies a definition in saying that a system includes more than a series and less than a group, and that the Jurassic is a system; but this gives only a meagre conception and we need a full one. As the problem of classification demands a true conception of a system, and as there is reason to believe that a false conception is abroad, it is proper that in seeking the true one we begin with the elements.

The surface of the land is constantly degraded by erosion, and the material removed is spread on the floor of the ocean, forming a deposit. This process has gone on from the dawn of geologic history, but the positions and boundaries of land and ocean have not remained the same. Crust movements have caused the submergence of land, and the emergence of ocean bottom, and these movements have been local and irregular, districts here and there going up while other districts went down. The emergence of ocean bottom exposes the deposit previously made on it and subjects it to erosion. In this way every part of the known surface of the globe has been the scene of successive deposition and erosion, and in many districts the alternations of process have been numerous. It is manifestly impossible that either erosion or deposition should have ever prevailed universally, and it has been established by the study of stratigraphic breaks that a time of erosion has often interrupted deposition in one region while deposition was uninterrupted in another.

In transportation from its region of erosion to its place of deposition detritus is assorted, and it results that the simultaneous deposits on the bottom of an ocean are not everywhere the same. Equal diversity is shown in the ancient deposits constituting geologic formations. It is a general fact that synchronous formations have not everywhere the same constitution.

Many of the variations in deposits are correlated with depth of water and distance from shore, and it results that elevation and subsidence in regions of continuous deposition produce changes in the nature of the local deposit.

The animals and plants of the earth are not universally distributed, but are grouped in provinces. In the geologic past similar provinces existed, but their boundaries were different, shifting in harmony with the varying geography of the surface. From time to time the barriers separating contiguous provinces have been abolished, suffering them to coalesce; and conversely new barriers have arisen, creating new provinces. From the earliest paleozoic to the present time the species of animals and plants have been progressively modified, the nature of the modification depending on local conditions. The faunas and floras of different provinces thus become different, and the longer the provinces remain distinct, the greater is the divergence of life. The removal of a barrier either produces a new fauna by the fusion of the two previously separated, or else obliterates one and extends the area of the other. In either case there is a change toward the unification of life, and in either case there is an abrupt change in a local fauna. Thus the secular evolution of species, combined with the secular and kaleidoscopic revolution of land areas, leads to two antagonistic tendencies, one toward diversity of life on different parts of the globe, the other toward its uniformity. The tendency toward uniformity affords the basis for the correlation of terranes by comparison of fossils; the tendency toward diversity limits the possibilities of correlation.

If now we direct attention to some limited area and study its geology, we find that under the operation of these general processes it has acquired a stratigraphic constitution of a complex nature. Its successive terranes are varied in texture. Breaks in the continuity of deposition are marked by unconformities. The fossils at different horizons are different, and when they are examined in order from the lowest to the highest, the rate of change is found to vary, being in places nearly imperceptible and elsewhere abrupt. It is by means of such features as these — that is, by lithologic changes, by unconformities, and by life changes — that the stratigraphic column is classified into groups, systems, series and stages. A system is a great terrane separated from terranes above and below by great unconformities, or great life breaks, or both. Smaller unconformities, smaller life changes, and lithologic changes are used for the demarcation of series and stages; and on the other hand, exceptionally great unconformities and life breaks are used to delimit groups. As the same criteria determine groups, systems and series, differing only in degree, the precise definition of

the term system is impossible, and in many cases the gradation of a terrane as a group, a system or a series is largely a matter of convenience. From this point of view a system is somewhat artificial, but there is a more important sense in which it is natural. It is limited by stratigraphic or paleontologic breaks above and below, and these breaks are natural. The taxonomist is not warranted in dividing systems where no such break exists.

Transferring now our attention to some other area, distant from the first, and studying its stratigraphy, we find that the same principles enable us to divide it independently into stages, series, systems and groups. Its fossils are not the same, but they are to a certain extent similar, and the sequence of life is approximately parallel. We cannot compare stage with stage, nor series with series perhaps, but we can compare system with system, and making the comparison we discover that the breaks are at different places. While one area was upraised and subjected for a time to erosion, the other received continuous deposition. While life in one area, enjoying constant conditions, was almost unchanged for long ages and even epochs, it was revolutionized in the other by the irruption across some obsolescent barrier of strong and aggressive faunas and floras. The systems of one area, therefore, do not coincide with the systems of the other in their beginning and ending. They may differ in number, and they may differ greatly in magnitude and in the duration they represent. They are in fact a different set of systems.

The case I have described is ideal but not false. It represents the common experience of those who have developed the geologic histories of remote districts and attempted to correlate them with the geologic history of Europe. There does not exist a world-wide system nor a world-wide group, but every system and every group is local. The classification developed in one place is perfectly applicable only there. At a short distance away some of its beds disappear and others are introduced; farther on its stages cannot be recognized; then its series fail and finally its systems and its groups.

If I have properly characterized stratigraphic systems — if they are both natural and local — it goes without saying that the classification of the strata of all countries in a dozen or so systems, as proposed by some of the members of the Congress, is impossible.

I hasten to add that from the point of view of these gentlemen what they advocate is not necessarily impossible, for they have a

different conception of a system. They regard it not as local but as universal. It is their privilege to define their terms as they please, and we will not dispute about mere words, but I cannot too strongly or too earnestly insist that a system which is universal is artificial. It may be natural in one geologic province, but it is artificial in all others. Take for example the Jurassic. It is a natural system in Europe. In the eastern United States no strata are called Jurassic with confidence, and at the west the rocks called Jurassic merge with those called Triassic. In India, Medlicott tells us, a Jurassic fauna occurs at the summit of a great natural system containing a Permian fauna near its base. In New Zealand, according to Hutton, a continuous rock system, dissevered by great unconformities from other systems, bears at top fossils resembling those of the lower Jurassic and lower down fossils of Triassic facies. To establish a Jurassic system in either of these countries it is necessary to divide a natural system, and a Jurassic system thus established would be necessarily artificial.

This is the sort of classification implied by the assumption that systems are world-wide. It is not impossible, but it is highly unadvisable. It is classification for the sake of uniformity, and its uniformity is procrustean. The natural systems of a region are the logical chapters of its geologic history. If you group its strata artificially according to the natural divisions of another region, you mask and falsify its history. The geologic history of the earth has as great local diversity as its human history. As in human history there are interrelations and harmonies and a universal progress, but these are perceptible only in the general view; and the student whose preconceptions lead him to exaggerate the harmonies and ignore the discrepancies perverts the meaning of every page.

I prefer therefore my own definition of system, making it natural and consequently local, and I earnestly oppose any attempt to coerce the geology of one country in a rigid matrix formed over and shaped by the geology of another country.

The ideas I oppose have arisen in connection with the work of correlation. Some geologists appear to regard correlation as the determination in distant localities of identities; the more philosophic regard it as the determination of the actual relations, whether they be of identity or difference. With the former the basis of correlation is the universality of geologic systems; with the latter it may be said to be the universality of geologic time.

Now in the comparative study of local geologic histories, just as

in the comparative study of local human histories, it is a matter of convenience to have a common scale of time. It is not essential, but it is highly convenient. In human history we use an astronomic scale of equal parts, designating each unit by a number. In geology no scale of equal parts is available, and we employ the eras and periods, and to some extent the epochs, of the local geologic history first deciphered — that of Europe. These time divisions bear the same names as the groups, systems and series of strata whose deposition occurred within them.

So far as the science of geology is concerned the selection of Europe as its first field of study was a matter of chance, and the adoption of the European time scale as a general standard may therefore be said to have been accidental. Though the local rock scheme on which it is based is natural, the time scale, considered as universal, is arbitrary. Another locality would have afforded a different scale, but its authority would neither be greater nor less. The scale being recognized as arbitrary, and a mere matter of convenience, it is legitimate to modify and fix it by formal convention. The Congress can do good service to geologic technology by putting it in the best possible shape and giving it an official status. In my judgment only a small number of divisions should be admitted, not more than the number of periods of the European scheme. In a general way the durations represented by the coördinate divisions should be as nearly equal as practicable, but a certain concession might be made to chronologic perspective on account of our superior opportunities for studying the later history. Some of the shorter periods might perhaps be united under new names. Each line of division between periods should be defined by means of a stratigraphic plane of division, and this can be done with precision if a locality is made part of the definition.

Especially should pains be taken to declare the arbitrary nature of the scale. Even with this precaution it will be misconstrued by many, for there is a tendency of the mind to attach undue weight to classification. Wherever we draw lines of separation we lose to a certain extent the power to recognize continuity. When, for example, the clock strikes twelve on New Year's Eve time seems to stop and begin again. We speak of the achievements of the nineteenth century — and despite ourselves we think of them, too — as though a new industrial epoch began in A. D.

1800. And so it is easy for the beginner in geology to accept as discontinuous the eras and periods of which his text-book treats, and it is hard for him afterward to unlearn the lesson.

There is reason to believe that confusion of ideas in regard to geologic classification has been fostered by the employment of the same set of names for the divisions of the time scale and for the local terranes on which they are founded. It might be well to furnish the time scale with names suggesting time — such names as the brothers Rogers applied to the terranes of Pennsylvania — but so radical a change is hardly feasible, especially as we should thus lose the mnemonic connection of times with corresponding terranes. I propose as a means of accomplishing the end with the least inconvenience, that a set of time words be derived from the terrane names by modifying the final syllables. The time words should all have the same termination, and that should differ from any terminations occurring in the terrane names. I suggest for the ending of time words the syllable *al*. With such a nomenclature Jurassic and Devonian would denote only certain European rock systems, while Jural and Devonal would denote periods of the standard time scale; and we could speak of the Chico-Tejon series as partly Eocenal and partly Cretaceal without seeming to imply the existence in California of the Eocene and Cretaceous systems of Europe.

A few minutes ago I opposed the differentiation of words by terminations because it abrogated the power of indefinite expression; I now favor it for the same reason. It is well to be indefinite as to the taxonomic rank of terranes while their characters are imperfectly known, but it is not well to confuse terranes with times.

It is not to be assumed that a time scale adopted now as the best possible will continue indefinitely to be the best possible; the day will inevitably come when it can be improved. In the fuller light of the future we may recognize as very unequal periods that we now deem equivalent, and the possibilities of defining pre-Cambrial periods are unlimited. Even now there are announced beneath the lowest fossil-bearing terranes of the Lake Superior region two systems of clastic rocks limited above and below by great unconformities, and Irving demands their recognition as a group, distinct from the Archean. If his voice is heard, the time scale

will include an era between the Paleozoal and the Archeal, and this era will supply the needs of the systematist until great additions have been made to our present knowledge of the older rocks.

My only remaining subject is the representation of terranes on maps by means of colors. At present no two organizations and scarcely two individuals use colors in the same way, and it is probably true that every organization and individual publishing many geologic maps has at different times employed the same color for different terranes and different colors for the same terrane. It results that the map user can gain no information from the distribution of colors until he has studied the legend; before he can read a new atlas he must learn a new alphabet. The advantage to be gained by substituting a universal language for this confusion of tongues is manifest and great, and has justified the application of much time and attention by the Congress and its committees. By a series of resolutions a partial scheme has been selected, one color at a time, and the completion of the plan has been left to the committee on the map of Europe. That committee has prepared a color legend which is accessible to American geologists in the volume of information published by the American committee. It is understood in a general way that the Congress reserves final action, and the published legend not only belongs specifically to the map of Europe, but is provisional; still, as this map, if generally approved, will unquestionably be declared by the Congress an authoritative pattern for the guidance of map makers, the plan should be freely criticised at its present stage. The selection of uniform colors is a far more delicate and important matter than the arrangement of taxonomic terms; for while ill-chosen words may quickly fit themselves to new uses, the adoption of an ill-arranged color scheme must entail continual loss.

In my judgment the scheme provisionally chosen is defective in several particulars, to which I shall presently call attention, but it is necessary to introduce the discussion by a statement of the conditions to be satisfied by a standard color scheme and a statement of the practical means available. The following are the principal conditions, arranged in an order embodying my estimate of their relative importance:

(1) The map must be clearly and easily legible. Each color must be so distinct from each other color that it can be identified,

whatever its surroundings; and all other conventions must be readily discriminated.

(2) The cartographic scheme must be adjustable to the geologic facts; it must not require that the facts be adjusted to it.

(3) The same scheme should serve both for general maps, as, for example, those representing only systems, and for detail maps, representing numerous smaller divisions.

(4) Undue expense should be avoided. The amount and consequent utility of color cartography is largely limited by its cost.

(5) It should be easily fixed and retained in the mind. This is best accomplished by making it orderly.

(6) Other considerations permitting, the map should please the eye. Since the arrangement of color areas cannot be foretold, this can only be accomplished by admitting a certain range of choice. If allowed sufficient latitude in the selection of tones, an expert colorist can ameliorate an offensive combination of hues.

(7) Other considerations permitting, the establishment of a universal system should involve the least possible inconvenience. But as the inconvenience of change is temporary, while the inconvenience of a bad system is lasting, this consideration should yield to every other.

The art of mapping geologic terranes by means of color is well developed, and its methods, viewed from the geologist's standpoint, admit of easy characterization. Color may be varied in two distinct ways — in hue and in tone. Hues differ in quality, as yellowish green and bluish green. Tones differ in strength, as pale green and dark green. A color is printed either solid or broken; it is said to be broken when applied in a pattern, as in lines or dots, or when it is interrupted by a pattern. The difference between solid and broken colors is a difference of texture. The primary discriminations in mapping are through hue, tone and texture.

The map engraver produces texture in three ways. In the first way a single impression is made with a broken color. The white of the paper, displayed where the color is interrupted, combines with the color in the general effect, producing a paler tone of the same hue. In the second way two impressions are made, one with solid color the other with broken, and the two impressions have the same hue; they may or may not differ in tone. This is

monochromatic overprinting, and its general effect agrees in hue with the single impression, but differs in tone, being darker. In the third way two impressions are made, one solid, one broken, and their colors differ in hue. This is bichromatic overprinting and its general effect differs in hue as well as tone from each of the colors combined in it. The first and second ways produce texture monochromatically and do not yield a new hue; the third way produces texture bichromatically and yields a new hue. It is practically impossible to obtain a texture effect without modifying the original tone.

The natural gradation from hue to hue is absolutely continuous and the number of hues is infinite; the number of tones of each hue is likewise infinite. The number of hues and tones the eye can discriminate is finite, but very great; it is stated that one thousand hues have been distinguished in the solar spectrum. But the number of hues and tones that can be combined in a map is small. As a matter of perception, every color is modified by the colors adjacent to it. The same hue affords different sensations when differently surrounded, and different hues may afford the same sensation. The same is true of tones; and there is a certain interdependence of hues and tones in this respect. In a geologic map each color is liable to fall into various combinations, and two colors little differentiated occasion confusion. There is, therefore, a somewhat narrow limit to the employment of hues and tones. The matter has not been fully worked out, but it is probable that twenty is as large a number of hues as can be safely employed in connection with tones. Texture admits of very great variation. The various color schemes submitted to the Congress and printed in the report of the Bologna meeting afford, with their manifest permutations, about two hundred distinct textures, and I am satisfied from a study of these and others that as many as one hundred can be chosen that are not subject to confusion. It follows that a map or atlas expressing few distinctions need use only hues, or only hues and tones, but where numerous distinctions are to be made, recourse must be had to textures.

The printing of a large number of textures of the same hue produces a greater number of tones than can be discriminated, and its effect is to confuse and nullify any distinctions (within the range of that hue) based purely on tone. The printing of a large number

of bichromatic textures causes the same result, and it also produces a greater number of hues than can be discriminated; its effect is to confuse and nullify distinctions based purely on tone, or on hue, or on tone and hue together.

In the color scheme prepared for the map of Europe thirty-eight distinctions are made. There are twenty-four hues, and the remaining fourteen distinctions are accomplished by variations of tone. While it may be possible to select twenty-four hues available for indiscriminate combination, there can be no question that those provisionally printed by the committee will fail to maintain their distinctness when variously combined upon a map. Under the influence of such chromatic environments as are sure to be encountered, the four yellow hues of the Tertiary cannot be discriminated, and the same difficulty will arise with the two hues of grey assigned to the Carboniferous, and with the hues of grey and brown assigned respectively to the Permian and the Devonian. Some of the tones likewise are not sufficiently distinguished. Two of the blues of the Jurassic, two of the browns of the Devonian, two of the rose tones of the Archean, and the two violets of the Trias are open to this criticism. A certain amount of adjustment can be made in the final selection of inks, and probably all the defects from tone can be thus remedied, but the confusion of hues is more difficult to eliminate, for the great number of the hues interferes with the separation of those that are too approximate. To strengthen one contrast is to weaken another.

In order to judge of the availability of the scheme for the production of detail maps, it is necessary to consider the resolutions of the Congress as well as the printed legend. A resolution provides that the subdivisions of a system shall be represented by shades of the color adopted for the system, or by broken color or other texture devices, and it is further provided that the shades, whether produced by solid color or by texture, shall be so arranged that the darkest or strongest represent the lower divisions of the system. The resolution is in French, and the word I have translated shade (*nuance*) is one which applies popularly to either hue or tone, while in the scientific terminology of chromatics it applies to hue only. The committee on the map has taken it in its popular sense, and has represented some subdivisions by hues, and others by tones; for example, Pliocene and Miocene are assigned

two tones of the same hue, while Oligocene and Eocene have each a separate hue. The upper Cretaceous and part of the lower Cretaceous are assigned a green hue in two tones, while the Gault and the Wealden, classed as subdivisions of the lower Cretaceous, have independent hues of green. Of the six reds assigned to volcanic rocks, two agree in hue and differ in tone, while the remainder have distinct hues. As the legend stands, both major and minor distinctions, that is to say, the discrimination of groups, the discrimination of systems, and the discrimination of divisions smaller than systems, are all accomplished by differences of hue, while the discrimination of minor divisions is accomplished indifferently by variation of hue and by variation of tone. The same means performs several functions and the same function is performed by several means.

It is stating the same thing from another point of view to say that the Congress and its committees have used the term color in its popular rather than its scientific sense. Scientifically, a color is a particular tone of a particular hue, and the number of colors is infinite. Popularly, a color is an assemblage of contiguous hues and their tones, to which a name has been given. Each hue and tone within the range covered by the name is a shade of the color. It is in this popular sense that the resolutions assign a color to each system, and assign shades of the system-color to the subdivisions of the system.

Now if in the variation of a system color, by textures or otherwise, a single hue is adhered to, the system-color remains distinct from other system-colors throughout all its modifications and their modifications, but if hues as well as tones are varied, the inevitable result is confusion, for some of the hues of one system-color will approach too near to hues of other system-colors. With a multiplicity of minor distinctions the main distinction of system from system will be lost.

Another difficulty lies in the fact that the Quaternary and Devonian colors, while strongly contrasted in tone, are nearly identical in hue. This does not affect their use in a general map, but in a detail map the stronger tones of the Quaternary grey will approach too closely the paler tones of the Devonian brown.

These criticisms apply to those features of the scheme which affect its adoption for general and detail maps of European countries. There is one of equal or greater importance affecting its application

in other continents. It is adjusted to the rock systems of Europe exclusively, and makes no provision whatever for the systems of other parts of the earth. The geologists of Wisconsin, for example, cannot use it without calling the Keweenawan either Cambrian or Archean. If they were in doubt which division should hold it, but inclined a little one way or the other, they could express their qualified opinion in the notation provided by the map committee; but having attained an unqualified opinion that the terrane belongs to neither of these two categories, they find no means for expressing their conclusions. The scheme cannot be applied to the geology of India, of New Zealand, or of Australia, without misrepresentation. It is not universal but local, and this because it is founded on the fallacy of a world-wide unity of geologic systems.

So far as the geology of the world is concerned, it would be better to adopt no convention at all as regards map colors, than to adopt one carrying with it and promulgating a vicious classification. Uniformity is not worth purchasing at the price of falsification. If the members of the Congress cannot agree upon a plan having the flexibility demanded by the geologic facts, it will be best to limit its action to the local problems involved in the map of Europe. I believe, however, that the necessary flexibility is attainable, and before proceeding to further criticism of the committee scheme I will give the outlines of a plan which appears to me to combine the advantage of flexibility with a number of other desirable qualities.

The plan is founded on the universality of geologic time and the diversity of local geologic histories as expressed in rock systems. Geologic periods are arranged in linear order. Each one adjoins the next and together they constitute continuous geologic time, which we may conceive as represented by a straight line. The stratigraphic systems of a country have likewise an order of succession, and their arrangement is linear. They are not always continuous one with another, but the history recorded by the systems and the breaks between them is continuous and may be represented by a straight line, equal and parallel to that of geologic time. And so for each country. A color scale which shall represent each and all of these parallel lines must be itself linear and continuous, and, fortunately, we have such a scale furnished us in the prismatic spectrum.

I propose, first, that the continuous prismatic spectrum be

adopted as the standard universal scale for continuous geologic time. I propose, second, that the conventional time scale, based on the geologic history of Europe, be complemented by a color scale, prismatic but discontinuous. I would assign to each period, not a certain portion or area of the spectrum, but a specific color defined by its position in the spectrum. This color scale will also apply to the geology of Europe. I propose, third, that the students of each geologic district shall assign to the stratigraphic systems of that district a set of prismatic colors so selected from the spectrum as to properly represent the relation of each system to the time scale, provided that relation is approximately known. Under this rule a system corresponding partly with the Cretaceous and partly with the Jurassic will receive a prismatic color intermediate between those assigned to the Cretaceal and Jural divisions of the time scale. I propose, fourth, that systems whose relations to the standard time scale are not even approximately known be given tentative positions in the time scale and assigned the corresponding colors; and that such provisional colors be distinguished by a special device.

Of this device I will speak later, but before we leave this part of the subject, the capability of the plan to express the facts should be more clearly characterized. Continuous geologic time being equated with the continuous spectral band of light, each period is theoretically equated with a segment of that band including all the hues between certain limits. But, practically, the period is represented in the color scale only by the central hue of the segment, and there is nothing in the nature of this hue to indicate the length of the segment. Similarly each local system is represented only by the hue corresponding to the middle of the equivalent period, considered as a part of the continuous time-scale, and this hue gives no information as to the magnitude of the system or the duration of the corresponding period. When a non-European system is represented on a map with the Devonal color, all that is expressed is that the middle of its period coincides with the middle of the Devonal period; the whole period may equal the Devonal or may be shorter or may be longer. With this limitation the scheme is able to express the exact facts, or the exact state of opinion, in regard to correlation.

I propose, fifth, that the subdivisions of systems be represented, if their number is small, by distinct tones of the hue assigned to

the system, and if their number is great, by monochromatic textures. It having been provided that systems shall be distinguished by means of hues, it is now provided that hues shall have no other function. This secures the integrity of the distinction between systems, whatever the minuteness of subdivision.

The idea of using the spectral colors in their proper order is not novel. It has entered into half the plans submitted to the Congress, but each author has introduced other colors also, or else has undertaken to use the spectrum colors more than once, under the impression that they do not afford the necessary range or variety. This impression is based largely upon the popular meaning of the word color. It is indeed true that if we limit ourselves to those parts of the spectral series which have univocal names, we have only six or seven distinctions; and it is further true that if we have recourse to binominal designations, such as yellowish green and greenish yellow, we obtain rather indefinite conceptions; but to men of science there are better resources than those afforded by the language of every day life. The spectrum has been elaborately studied, and the relations of its dark lines to its colors have been determined. Its wave lengths have, moreover, been measured, and by such means as these we are furnished with three different scales, any one of which is adequate to the precise definition of any hue of the continuous series. What needs to be done is this. When the divisions of the time scale have been decided on, the spectrum must be studied to ascertain the best selection of hues. Their number must, of course, be that of the number of divisions of the time scale, and they must be so chosen that the degree of separateness of adjacent colors shall be everywhere the same, as judged by the normal human eye. Then define each hue by its wave length, or its position in the Kirchhoff scale, and define it also in terms of the best combination of pigments with which it can be approximately reproduced for practical use. It is of course impossible to copy the prismatic colors with accuracy, because the colors of pigments are impure, but this difficulty will not seriously interfere with the employment of the prismatic colors as a standard.

The practical question whether the spectrum will give a sufficient number of hues so far separated from each other as to be distinguishable in all the arrangements occurring on maps has received such consideration as I have been able to give it, and it is my judgment that the maximum number of hues that can safely be

used falls somewhere between fifteen and twenty. There will certainly be no difficulty in thus constructing a standard color scale with about a dozen terms.

The employment of the spectral colors in this manner leaves three groups of colors unassigned; the purples, the browns and the greys. If the spectral colors be arranged on the circumference of a circle so that each diameter of the circle connects hues that are complementary, it is found that they occupy the greater part, but not quite all, of the circumference, and the color needed to fill the vacant arc is purple. The hues of purple might then, if deemed necessary, be added to one end or the other of the spectrum, thus increasing the range from which to select colors for the time scale.

My sixth proposition is to assign the browns to volcanic rocks. I would leave the greys unassigned.

It will be observed that no intimation has been given as to whether the violet end of the spectrum should apply to the newest system of strata or the oldest. It must of course be definitely assigned to one or the other, but the particular assignment is a matter of indifference.

The main features of the proposed prismatic scheme have now been set forth and you are fairly entitled to exemption from the minor features, but there is one detail that can hardly be omitted. In one of the main propositions it was provided that some special device should distinguish colors assigned to uncorrelated systems, and I feel it incumbent to show that a suitable device can be found. Of a number that have occurred to me as about equally available, I will mention but a single one — the overprinting, in small dots, widely separated, of the complementary color. The complementary color is selected because it does not disturb the relation of the system-color to the colors of adjacent systems. Bichromatic overprinting produces a hue intermediate between the two hues combined, but the hue midway between a system-color and its complementary color is white or grey, and if only a small amount of the complementary color is added, the system-color becomes merely paler or duller, when viewed from such a distance that the colors blend.

The prismatic color scheme having been constructed for the express purpose of securing a degree of flexibility that will fit it for universal use need not be further compared in that regard with the scheme published by the European map committee. Enough has

also been said to show that its superior perspicuity is claimed both for general and for detail maps. A few words will suffice to compare the two systems in other respects.

As regards the expense incurred in the production of general maps, neither scheme has notable advantage, and they are not yet sufficiently developed to permit a comparison as regards the cost of detail maps. Their capability for the production of pleasant color effects can be best judged when maps have been actually made, but it may be said in a general way that the committee's scheme will afford more strong contrasts between adjacent color areas than the prismatic. The maps colored by the former will be relatively lively, those colored by the latter relatively quiet. It is provided by the committee that the volcanic colors shall be not merely red but strong. On a general map volcanic areas cover comparatively small spaces, and strong reds thus disposed will ordinarily add brilliancy; but the detail map of a volcanic district, thus colored, will be disquietingly suggestive of active eruption.

The alphabet of colors for the prismatic scale will be the more easily learned of the two, because it is orderly, and because its order is already familiar in the spectrum. The committee's scheme, however, has some old-fashioned mnemonic features which the prismatic lacks. The green of the Cretaceous is connected with greensand, the red of volcanic rocks with fire, and the rose of the Archean with feldspar; and the grey of the Carboniferous mildly suggests the blackness of coal.

In respect to facility of introduction the committee's scheme, being essentially a compromise of existing color scales, has the advantage that to most users it is not entirely novel. The prismatic scheme on the other hand has the advantage of being orderly. It scientifically differentiates the functions of hues and tones, and though each one of its colors may be different from what the individual geologist has previously employed for the indication of the same system, the order of the colors is already familiar to him in another way.

This closes my review of the various works undertaken by the Congress. Some of these have been favored, others opposed, and reasons have been given. But there is a general consideration or criterion applicable to all which has nearly escaped mention, although it is of preëminent importance. When a matter is pro-

posed for regulation by the Congress, the first question which should be asked is whether it falls within the legitimate purview of a convention of geologists. It manifestly does not, if it belongs to some other science rather than to geology, and objection has on this ground been made against the regulation by our geologic Congress of the nomenclatures of paleontology and mineralogy. But not all geologic matters even are properly subject to settlement by convention. This is peculiarly the case with geologic facts. Science is distinguished from the earlier philosophies of mankind by the peculiarity that it establishes its fundamental data by observation. The old philosophies were founded largely upon assumptions, and it was not deemed illogical — perhaps it was not illogical — to appeal to the authority of an assemblage of experts for the establishment of fundamental assumptions. But for science it is not merely illogical, it is suicidal, to establish facts in any other way than by observation. No vote of the most august scientific body can possibly establish a fact, and no vote can have any weight against a good observation.

Now the entire science of geology, using the phrase in a strict sense, is constituted by the aggregation and arrangement of facts, and none of its results can be rendered more true, or be more firmly established, or be prevented from yielding to contradictory facts, by conventional agreement. A classification, if it has any value whatever, is merely a generalized expression of the facts of observation, and is outside the domain of the voter. If it comprises all the essential facts, its sufficiency will eventually be recognized, whether its authority is individual or collective. If it does not comprise them, it will inevitably be superseded, by whatever authority it may have been instituted. For this reason I am opposed to the classification by the Congress of the sedimentary formations, and likewise to the classification of the volcanic rocks, and I also regard it as ill-advised that the Congress undertook the preparation of a map of Europe, for that—if more than a work of compilation—is a work of classification.

If we examine the other undertakings of the Congress — the definition and gradation of taxonomic terms, the systematization of terminations, the selection of a scale of colors for geologic maps, and the selection of other conventional signs for the graphic expression of geologic phenomena—we find that they all belong to the means of intercommunication of geologists. They affect only

the verbal and graphic technical language of the science. Of the same nature is the arbitrary time scale whose preparation I favor, — a conventional terminology for the facts of correlation. So we may say in general, that the proper function of the Congress is the establishment of common means of expressing the facts of geology. It should not meddle with the facts themselves. It may regulate the art of the geologist, but it must not attempt to regulate his science. Its proper field of work lies in the determination of questions of technology; it is a trespasser if it undertakes the determination of questions of science. It may decree terms, but it must not decree opinions.

PAPERS READ.

On the different types of the Devonian in North America. By Prof. H. S. Williams, Ithaca, N. Y.

[ABSTRACT.]

The Devonian outcrops of America are classified into four areas, each of which has its distinctive characters: physical, lithological, stratigraphical and biological.

1. An eastern border area, presenting much resemblance to the old red sandstone type of Great Britain, and biologically having mainly vertebrates and plants as distinctive features.

2. An eastern continental area with a full series of distinct stratigraphical divisions, and biologically marked by numerous temporary faunas, mainly of marine invertebrates.

3. An interior continental area with a short section of mainly calcareous rocks, following limestones below and running into limestones above, and representing faunally the middle marine fauna of the east with, at its base, traces of the lower fauna and at its top traces of the upper fauna.

4. A western continental area with thick and continuous limestones below, terminating above in thick masses of shales, but faunally presenting a remarkable blending and continuance of the general Devonian marine faunas from bottom to top, with, however, a clear indication of Lower Devonian at the base and of Upper Devonian at the top.

These four types of the Devonian are not capable of coördination in any of the details of lithology or stratigraphy and in terms of biological conditions, although presenting clear evidence of representing the same position in a geological scale, are capable of only a general kind of uniform subdivision into lower, middle and upper, and any attempt to fix a classification which is appropriate to one upon either of the other would be forced and misrepresent the facts as found in nature.

The problem of unification of classification, as tested by this single sys-

tem as exhibited in North America alone, is shown to be impracticable whenever the distinctive characters are physical (*i. e.*, stratigraphical, lithological or structural), and where the criteria are biological a uniform classification or nomenclature is not practicable in the present stage of science except in the recognition of grand divisions about equivalent to what are called systems, and indefinite subdivisions of these into lower, middle and upper stages of the system.

And if this be the conclusion when a single continent is considered, it is not reasonable to attempt to force unification of classification beyond this point when other continents are concerned.

SECTION OF THE LOWER DEVONIAN AND UPPER SILURIAN STRATA IN CENTRAL NEW YORK, AS SHOWN BY A DEEP WELL AT MORRISVILLE. By CHARLES S. PROSSER, Cornell University, Ithaca, N. Y.

[ABSTRACT.]

A WELL was drilled for natural gas at Morrisville, Madison county, New York, to the depth of 1,889 feet. Altitude of the well's mouth is probably more than 1,200 feet A. T.

The well commences in the lower half of the Hamilton, and then passes through the Marcellus shale; Corniferous limestone; Oriskany sandstone; Lower Helderberg limestones; limestones, marls and shales of the Salina; Niagara (?) and ends in the upper Clinton.

The united thickness of the Corniferous, Oriskany and Lower Helderberg is 279 feet, of which 186 feet is probably Lower Helderberg. The Salina of this section consists of 325 feet of hydraulic limestone, 590 feet of shales, impure limestone and marls, closing with 225 feet of red shale. Total thickness of Salina, 1,140 feet. At 1,805 feet is a blue, argillaceous shale which may be Niagara.

Gas was obtained at 578 feet and in smaller amount at 755 feet, but not in quantity enough to be of economic value. A stratum of rock salt, 10–12 feet thick, was reached at 1,259 feet in the upper part of red and green variegated marls. Samples from 1,805 and 1,815 feet show traces of salt.

I am indebted to Mr. W. W. Hague for the specimens illustrating this section, and also to Mr. E. M. Hague and Capt. H. H. Cumings for additional information.

The accompanying section gives the most important facts of the well.

MORRISVILLE WELL.

DEPTH.	THICKNESS.	
		Hamilton.
340′		Marcellus, first sample.
371′		Corniferous limestone.
		441′ (?) Horizon of Oriskany sandstone.
	79′	
578′		Gas. Lower Helderberg limestone.
	2	
650′		
	5′	
755′		Gas.
	83	Hydraulic limestone.
975′		Light gray shale.
1018′		5′ of dark red shale.
	87′	Green and blue marls.
1110′		
1179′		
	36	Limestone?
1215′		
1259′		10′–12′ of rock salt.
	141′	Red and green variegated marls.
1400′		
	60′	Red marl.
1460′		
	105′	Green and blue marls.
1565′		
	225	Red shale.
1790′		
1805′		Blue shale and limestone. Niagara?
1849′		25′ blue shale.
874′		Blue shale and limestone. Clinton.
1889′		

SALINA. 1140′

THE UPPER HAMILTON OF CHENANGO AND OTSEGO COUNTIES, NEW YORK.

By CHARLES S. PROSSER, Cornell University, Ithaca, N. Y.

[ABSTRACT.]

IT will be remembered that the "Onconta or Montrose sandstone" of Vanuxem was for a long time considered the lower portion of a continuous Catskill section. Later, above 500 or 600 feet of Vanuxem's Oneonta sandstone, shales were found containing an abundant Brachiopod and Lamellibranch fauna. Since then the lower red and gray sandstones have generally been called the Oneonta group. Below these sandstones are the Ithaca and Portage groups of the State Report, which have been considered by recent writers as Upper Hamilton.[1]

From a study of the region in question it is believed that the following stages have been determined between the Oneonta sandstone and undoubted Hamilton.

1. A series of shales and sandstones, 300 feet in thickness, the middle portion of which contains numerous fossils. Some of the most common are:

Paracyclas lirata, Con.
Chonetes scitula, H.
Tropidoleptus carinatus, Con.

The fossils gradually diminish in number towards the upper and lower portions of this stage and finally stop. 230 feet of these shales may be seen in the lower part of the high hill west of Norwich, and about 200 feet in the lower portion of the hill near Oneonta. This fauna is the Oneonta group of Conrad[2] (not Vanuxem) and in 1885 was called by Dr. H. S. Williams the *Paracyclas lirata* stage of the Hamilton fauna.[3] In the lower part are thin, blue flagstones which are the "Sherburne flagstones" of Vanuxem.

2. Blue shales which change to sandstones and coarse, arenaceous shales at the bottom. Fossils are very rare and the zone is at least 75 feet thick in the Chenango valley.

3. Black, argillaceous shales, 20 feet in thickness near Smyrna. The Genesee shale of the State Report.

4. Limestone layers, separated by calcareous shales, with a total thickness of 25 feet. Eastern exposure of Tully limestone near Upperville in Smyrna township.

5. Below the limestones are shales containing a typical Hamilton fauna.

Farther east in Otsego county, Conrad's Oneonta group and the barren shales below are clearly shown; but I was unable to find the black shales or limestones.

These investigations were undertaken at the request of Dr. H. S. Williams and may serve as a contribution to the elaboration of the details of Devonian stratigraphy upon which he is still at work.

[1] See Proc. A. A. A. S., Vol. XXXIV, pp. 229 and 233-4. Pal. N. Y., Vol. V, Pt. I, Lamell. II, pp. 517-8 and 326.
[2] N. Y. Ann. Geol. Rep., 1841, pp. 30, 31, 50 and 53.
[3] Proc. A. A. A. S., Vol. XXXIV, p. 225 and chart.

THE GRANITE AND QUARTZYTE CONTACT AT THE AURORA MINE, GOGEBIC IRON RANGE, AT IRONWOOD, MICHIGAN. By Prof. N. H. WINCHELL, Minneapolis, Minn.

[ABSTRACT.]

THIS paper described the field appearances, particularly the nature of the granite and the quartzyte, and their manner of superposition, the latter being illustrated by a diagram. The conclusion derived is that the granite is eruptive, but is the product of local fusion of a member of the Huronian, and hence that it should not be assigned to the Laurentian, as done by the geologists of Wisconsin.

GEOLOGICAL SECTION OF SOUTHWESTERN OHIO. By Prof. JOSEPH F. JAMES, Miami Univ., Oxford, Ohio.

[ABSTRACT.]

A WELL was bored for oil or gas at Oxford, Ohio, at a point 900 feet above the sea level. The drill passed through various strata to a depth of 1,365 feet when salt water was struck. The first forty feet was drift. Then came about 360 feet of blue limestone and shale interstratified. Beneath this was 380 feet of compact blue shale, and at 787 feet the division between the Cincinnati group and the Trenton was found. This was forty-seven feet thick and was a dark, hard, nearly black limestone. At 835 feet a white limestone was found which was the upper part of the Trenton. This continued with little variation till 1,280 feet was reached, and it seems the equivalent of the Birdseye limestone of New York. At 1,280 feet the rock was coarser and till 1,325 feet was reached was of about the same character. This may be referred to the Chazy of New York. Immediately below this the rock changed again and became arenaceous. Thus the Trenton in this section was about 500 feet thick and the Calciferous sand-rock was found immediately below it. This was penetrated for forty feet, and then salt water being found, the drilling was stopped. Samples from eighty-seven depths were saved and examined, and the section made by the aid of these. This is the first well, of which there is an authentic record, which has passed through the Trenton in southwestern Ohio.

SECTION OF LOWER SILURIAN (ORDOVICIAN) AND CAMBRIAN STRATA IN CENTRAL NEW YORK, AS SHOWN BY A DEEP WELL NEAR UTICA. By CHARLES D. WALCOTT, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

THE speaker described a well, drilled to the depth of 2250 feet, on the farm of the late Hon. Samuel Campbell, three miles west of Utica. Sections, of the strata penetrated by the well, were given as known from the

nearest surface outcrops, and comparisons made between them and the well section.

In the following table the two are combined; the well record stopping at 2,100 feet, as the data pertaining to the lower 150 feet was considered unreliable.

FORMATION.	WELL. Feet.	SURFACE OUTCROPS. Feet.
1. Hudson River.	90[1]	150
2. Utica Shale.	710	600
3. Trenton limestone, including Black River and Birdseye.	350	290
Gap, between Trenton and Calciferous, from which drillings were not preserved. Of this probably 100 feet should be referred to the Calciferous.	180	
4. Calciferous and arenaceous strata.	260	350
5. Potsdam (?) sandstone. With this there are probably included the pre-Cambrian strata, between the Potsdam and Archean, as seen at Little Falls, N. Y.	410	1
6. Pre-Cambrian and Archean.	100+	150
	2100+	1541

This is the first known section in the Mohawk Valley where the strata, between the base of the Oneida conglomerate of the Silurian and the gneiss of the Archean, have been measured and the relative thickness of the formations determined. Fossils were found in the chips from the Trenton limestone, but not from the rocks beneath.

DISCOVERY OF FOSSILS IN THE LOWER TACONIC OF EMMONS. By CHARLES D. WALCOTT, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

FOSSILS IN THE QUARTZITE.

SEVERAL localities of fossils were reported in the Geology of Vermont, pp. 356 and 357, as occurring in the Granular Quartz of the Taconic system; but, on investigation, the specimens proved to have been obtained from drift bowlders and not from rocks *in situ*, except in the case of Scolithus, which is a fossil of little stratigraphic value. When engaged in work in connection with the U. S. Geological Survey I traced bowlders containing fossils to an outcrop of quartzite, two miles east of Bennington, Vt., in which the following species of Middle Cambrian fossils were

[1]The well starts sixty feet below the summit of formation.

found *in situ: Hyolithes*, like *H. communis*, *Nothozoe Vermontana*, *Olenellus asaphoides*. Four hundred feet in thickness of quartzite is shown in the section, and the fossils occur from thirty-five to eighty-five feet from the base of the exposed strata. The quartzite was traced north into the valley of Roaring Branch in the town of Woodford and across the valley to the southern and western slopes of Bald Mountain. To the south, the quartzite extends along the western slope of the ridge leading to Dome Mountain in Pownal, northeast of Williamstown, Mass. It caps the latter mountain and crosses the valley to the Clarksburgh group of mountains, along the slopes of which it extends to a point opposite Williamstown and then east to North Adams, Mass. On the western summit, towards Williamstown, the quartzite is in contact with the pre-Cambrian gneiss; and fragments of a trilobite were found about 100 feet above the contact.

FOSSILS IN THE EASTERN LIMESTONE.

Up to August 5, 1887, determinable fossils had not been found to the writer's knowledge in the limestone east of the Taconic range or the second great formation of the Taconic system. The fossils discovered by Professors Dana and Dwight were from the western side of the range, and were referred to the Sparry limestone or Upper Taconic by writers favoring the view of the pre-Cambrian age of the Stockbridge or Eastern limestone. The fossils to which I now call attention were found in the Eastern limestone, in the town of Pownal, Vt., about half a mile north of the Massachusetts line. The fossils were weathered out in relief on the surface of a light-colored clouded compact marble. The identified forms are *Maclurea? Murchisonia bellacincta? M. Milleri? Raphistoma* sp.? and a large crushed gasteropod shell. The fauna belongs to the Trenton-Chazy terrane and correlates the Eastern or Stockbridge limestone with the Western or Sparry limestone.

The discovery of determinable fossils in the quartzite and the Eastern limestone of the Lower Taconic united with the data obtained from the Western limestone and the Taconic slates in Washington county, practically puts at rest the question of the geologic age of the Taconic system. We now know positively that the quartzite series and the Upper Taconic are of Cambrian age, and the limestone series with the overlying schists are of Lower Silurian (Ordovician) age.

NOTES ON THE BEREA GRIT IN NORTHEASTERN OHIO. By H. P. CUSHING, Cleveland, Ohio.

THE sections run from the base of the Sharon Conglomerate at the top down to the base of the Bedford Shale, or its probable equivalent at the bottom, or as near to that horizon as possible.

1 Conglomerate		
Shenango Shales.	50'	280'
Shenango Sandstone.	25'	
Meadville Shales and Flags.	66	
Sharpsville Sandstone.	64'	
Orangeville Shales.	75'	
Corry Sandstone.	20'	
Cussewago Shales.	37'	
Cussewago Sandstone.	25'	

2 Conglomerate.		
Unexposed.	40'	235'
Shenango Sandstone.	15'	
Cuyahoga Shales and Flags.	90'	
Warren Sandstone.	50'	
Berea Shale.	40'	
Berea Grit.	35	
Bedford Shales.	15'	

3 Conglomerate.		
Unexposed.	130'	210'
Warren Sandstone.	25'	
Berea Shale.	55'	
Berea Grit.	10'	

4 Conglomerate.		
Cuyahoga Shales.	100'	100
Berea Grit.	40' to 60'	
Bedford Shale.	35'	

5 Conglomerate.		
Cuyahoga Shale.	150' to 200'	150' to 200'
including		
Berea Shale.	15'	
Berea Grit.	60'	
Bedford Shale.	75'	

No. 1 is Prof. I. C. White's general section in Erie and Crawford Counties, Pa. No. 2, my section in Ashtabula and Trumbull Counties, Ohio, near Pa. line. No. 3, my section through Warren, Trumbull County, Ohio. No. 4, M. C. Read's general section in Ashtabula and Trumbull Counties, Ohio. No. 5, Dr. Newberry's general section in Cuyahoga County, Ohio.

In the Waverly Group, throughout the larger part of northern Ohio, there is one strong persistent sandstone horizon, and but one, the Berea Grit. In tracing its outcrop to the east, Mr. Read, when near the state line, came upon three sandstones near this horizon all resembling some lithological phases of the Berea. He concludes that the Berea here has split into two parts, or possibly even into three. The dark blue or black shales with black slate fauna, which he found lying between his two lowest sandstone members, he called Bedford shales, thus putting part of his Berea below the Bedford. This same shale which he calls Bedford in Kinsman township, he makes do duty as Cuyahoga shale—Berea shale of Prof. Orton—in Vernon township and at Warren. In my section near Warren the lower two of these three sandstones appear. The upper one of the two is the stone quarried near Warren and, according to the Ohio Reports, lies in the Cuyahoga shale. It is here considerably thinner than on the state line; directly under it the black Berea shale appears. This stone is *beyond doubt* the equivalent of the middle sandstone near the state line, that is as certainly the equivalent of the Sharpsville sandstone of Prof. White in Crawford County, Pa. North of Warren another sandstone appears directly under the black shale and is the equivalent of the lowest sandstone on the state line, of the Corry sandstone of Prof. White in Pa., of the Berea of Northern Ohio. That it is the Berea is shown:

1. By the hard, black, sandy, sulphurous layer, two inches thick, which separates it from the black shale above. This stratum occurs nearly everywhere above the Berea in Ohio and I did not find it above either of the other sandstones at this point.

2. By the nearly black shale, with a black shale fauna, which directly overlies it, and whose stratigraphical relations (as exhibited in the sections) show that it could not possibly be the Cleveland shale.

3. By the series of blue shales and flags, Bedford, underlying it.

4. By the fact that neither of the other sandstones here can represent the Berea. The upper is too near the Conglomerate and is underlaid by 100 feet of strata with Cuyahoga shale fossils. The middle one is the equivalent of the sandstone at Warren, and apparently nearly runs out just west of that point, being shaly and having only about a thickness of six feet in the Mahoning river, west of Warren. The work so far done would seem to show that Prof. White is right in his claim that the Corry sandstone is the equivalent of the Berea, which thus lies from 200′ to 230′ below the Conglomerate in Ashtabula and Trumbull Counties, instead of 100′ as Mr. Read gives it. This interval increases as we go east, slightly diminishes westward, and then rapidly increases toward the south.

NOTES UPON THE TEXAS SECTION OF THE AMERICAN CRETACEOUS. By ROBERT T. HILL, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

OWING to its peculiar transitional geographic position and the favorable conditions of exposure of its strata, the state of Texas presents the best opportunity for the study of the American Cretaceous, which has there the most comprehensive vertical range. Both the Gulf series or Mississippi section of Hilgard, except the problematical littoral Eutaw formation at its base, and the Rocky Mountain series or Nebraskian section of Meek and Hayden extend into the state by direct stratigraphic continuity, and their relation to each other can be easily studied. In this paper the confusion of opinion concerning the strata of the region incident to the stratigraphic errors of Rœmer, Shumard and others is cleared up, and the existence there beneath the Dakota sandstone of the Meek and Hayden section, of an older deep marine group of sediments previously mentioned in a paper read before the Philosophical Society at Washington, Jan. 29, 1887 (see Am. Jour. Science, April, 1887) is demonstrated by paleontologic and stratigraphic data. The faunas of this new group have great resemblance to the lower portion of the middle and to the Neocomian or Lower Cretaceous of Europe which is contrary to the hitherto accepted theory that there existed in this country an hiatus of all the lower Cretaceous strata, from alleged Wealden to the upper portion of the Middle Cretaceous (Dakota sandstone).

The paper is accompanied by lists of the species characteristic of each of the principal divisions of the Cretaceous as seen in Texas, and shows the stratigraphic horizon, range and distribution of numerous species heretofore described from that region, but unaccompanied by these essential data.

In conclusion, the author affirms that any present attempt at other than a provisional nomenclature of the American Cretaceous, until this Texas region is more critically studied, is premature and will tend to increase confusion.

NOTES ON THE GEOLOGY OF FLORIDA. By L. C. JOHNSON, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

THIS paper shows that all the northern and middle portions of Florida may be divided longitudinally into four regions, plainly recognizable by surface and soil indications, *i. e.*, 1. The gulf hammocks westward of the line of the great sand dunes; 2. A central region of lime sinks; 3. The lake region or region of the high hammocks; 4. The eastern slope region.

The rocks which underlie the second or limesink division belong, as

heretofore shown, to the Vicksburg horizon of the Tertiary. Overlying this, and outcropping as a border on each side of the central area of outcrop of this Eocene or Vicksburg limestone, is a nummulitic rock one hundred feet maximum thickness, supposed to be of true Oligocene age.

Overlying the Oligocene and outcropping on each side of it we find whitish calcareous beds containing much phosphatic material and holding a number of fossils of undoubted Miocene age.

The Miocene rock above noted is bordered by more recent deposits containing shells which are undistinguishable from those now living in the adjacent waters. These deposits underlie the eastern slope region. The Miocene forms the substratum of the hammock regions, but isolated deposits of it are also found within the region of the limesinks overlying the Vicksburg limestone of that region. The thickness of the Miocene beds has not yet been determined.

THE UPPER EOCENE LACUSTRINE FORMATIONS OF THE UNITED STATES. By Prof. W. B. SCOTT, Princeton, N. J.

[ABSTRACT.]

THE Bridger formation I consider to be divisible into three well-marked portions: 1. The Wind river at the base, which is characterized by many Wahsatch genera such as *Coryphodon*, *Phenacodus*, etc., by many true Bridger forms and by the peculiar genus of the Dinocerata *Bathyopsis*. 2. The Bridger basin has a very rich fauna of mammals from which *Coryphodon* and *Phenacodus* are absent, and *Uintatherium* is exceedingly abundant as well as a host of small creodonts and lemuroids. 3. The Washakie or Bitter Creek basin is usually considered contemporary with the Bridger basin proper, but it shows important faunal differences, in the great reduction of the creodonts and lemuroids, in the different type of the Dinocerata, in the presence of *Amynodon* and in the fact that very few *species* are common to the two basins.

It is generally stated that these Washakie beds lie conformably upon Wahsatch beds, but this has not been clearly established, and some facts in the topography of the region are against it. At the same time it is possible that the faunal differences between the Washakie and Bridger basins is geographical and not geological. The Uinta formation is at the top of the Eocene and forms the transition to the Miocene. It is chiefly remarkable for the absence of the Dinocerata and Tillodonta and for the great number of artiodactyls which occur in it. Several Bridger genera, such as *Amynodon*, *Hyrachyus*, *Plesiarctomys* and *Mesonyx* occur in these beds, but no genus has yet been found common to them and overlying White River beds.

"Lake Cuyahoga:" a study in glacial geology. By Prof. E. W. Claypole, Akron, Ohio.

[ABSTRACT.]

This paper gives an account of the condition of the Cuyahoga valley at the time when the North American ice-sheet had retreated beyond the line of the Ohio watershed but still occupied the basin and the south shore of Lake Erie, blocking all drainage to the northward. The ice-dam then lying across the Cuyahoga valley, by damming the water, produced a lake whose waters necessarily rose until they found an outlet at the lowest accessible point of the watershed by which they escaped southwardly to the Ohio River.

This lake measured at some times at least in its history ten or twelve miles long by from three to six miles wide. Its depth at the northern end was about 300 feet, lessening gradually to the southward. It found an overflow through a valley that divides the city of Akron into two parts and is occupied by the Ohio Canal whose highest reach on Summit Lake is 396 feet above Lake Erie.

The level of this "Lake Cuyahoga" was of course determined by that of its outlet "the Akron River" flowing through the gap at its southern end. This was in all probability somewhat lower than at present.[1] As a standing testimony to the existence of this lake the valley of the Cuyahoga is now clogged with a mass of silt containing a few stones—such as are usually deposited by glacial lakes — whose upper surface forms a terrace at the height of about 360 to 370 feet above Lake Erie. A long existence seems to be proved for this lake by the great thickness of the bed of silt which in some places, especially near its northern end, cannot be less than 200 feet.

[For the full paper of which the foregoing sentences are an abstract see the Transactions of the Edinburgh Geological Society for 1887.]

Glacier erosion in Norway, and notes upon northern ice action. By Prof. J. W. Spencer, University of Missouri, Columbia, Mo.

[ABSTRACT.]

The following notes are from personal observations in Norway during the summer of 1886.

(*a*) As many of the Norwegian glaciers are rapidly advancing, they arch over from rock to rock, and leave subglacial caverns into which the explorer can go long distances.

(*b*) Numerous angular and subangular stones, as well as those rounded by atmospheric erosion, are resting upon the crystalline rocky beds with the ice flowing about them; that is to say, the resistance due to the fric-

[1] Later observations show that the difference was very little.

tion between the stones and the rock is greater than the cohesion of the molecules of the ice, which flow about the obstacles as a viscous body does. Even stones resting upon the loose and soft morainic matter, over which the glacier is advancing, are sufficient to channel the ice as it moves over them.

(*c*) No blocks were seen in the act of being torn up from the subjacent rock, nor were the loose stones being picked up.

(*d*) A large rounded boulder, held in the ice, was being rolled, in place of shoved, along by glaciers, as shown by the mouldings in the ice. At the same time, it was being crushed.

(*e*) The abrasion by the falling of detached masses of ice and stones is considerable.

(*f*) A tongue of ice, hanging from the roof of a cavern, was pressing against a loose boulder, that a man could have moved. In place of pushing the stone, or moving around it, the suspended tongue of ice (about a cubic yard), was bent backward, nearly at right angles, in a graceful curve.

(*g*) Scratched stones were rarely seen among those falling out of the bottoms of glaciers, and in many places the rocks were scarcely, if at all, scratched. Although occasionally highly polished, the subjacent rocks, even where scratched, showed generally surfaces roughened by weathering, or with only the angles removed.

(*h*) The upper layers of ice were seen to bend and flow over the lower, wherever low barriers were met with, in place of the lower strata being pushed up by an oblique thrust.

(*i*) A glacier was advancing into a morainic lake, and in part, against the terminal barrier. In place of ploughing up the obstruction, the strata of ice was forced up into an anticlinal, along whose axis there was a fracture and fault. Thus domes of ice covered with sand were produced. The sand had been deposited upon the surface of glaciers by the waters of the lake. The conformability of the sand and the strata of uplifted ice was undisturbed, except along the line of fault. As the domes melt, cones of sand with cores of ice are left. By the lifting process the morainic barrier is covered with clayey sand, as if subjacent strata had been ploughed up by the glacier, of which there was no evidence.

(*j*) At several places where glaciers are advancing over moraines, they are levelling them, and not ploughing them out. This levelling process is by the dripping of the water from the whole under surface. In fact, even the loose stones upon the water-soaked moraines were sufficient resistance to cause the bottom of the ice to be grooved.

(*k*) The fall of a great ice-avalanche from a high snow-field, down a precipice of a thousand feet, to the top of a *glacier rêmanié* was seen. These falling masses of ice bring down the frost-loosened stones from the sides of the mountains upon the glacier, which is charged with *detritus*. It is this material which furnishes mud to the subglacial streams, and not the rocky bed of the valley worn down by glacial erosion.

(*l*) One does not find that the glaciers *per se* are producing rock-hum-

mocks. These are the result of atmospheric and aqueous erosion, although perhaps beneath a glacier, which sweeps over them and to some extent scratches and polishes them. The effects of glaciation in removing angles and in polishing surfaces are small compared with atmospheric erosion upon the same rocks.

(*m*) The transporting power of glaciers is limited to the *débris* which falls upon its surface from overhanging or adjacent cliffs, and afterwards works through the mass or comes to be deposited at its end.

The above observations are in accord with phenomena seen by various explorers in Franz-Joseph Land, in Spitzbergen, in Grinnell Land and in Labrador, in which places floeberg-ice is modifying terrestrial features in a manner commonly attributed to glaciers.

NOTES UPON THE THEORY OF GLACIAL MOTION. By Prof. J. W. SPENCER, University of Missouri, Columbia, Mo.

[ABSTRACT.]

THIS paper is a rider to the last.

From the flowing of glaciers about loose obstacles, with consequent grooving of their lower surfaces; from the movement of upper layers of ice over the lower, where the mass meets obstacles; from the bending of tongues of ice rather than the dislodging of loose stones against which they impinge; and from the crushing of a large, rounded, granitoid boulder, resting upon a hummock, as it was rolled (not pushed) along by the glacier (that covered the stone by only thirty or forty feet), which rose up the ice-falls 2000 feet or more, whose weight could only be transmitted against the stone, by acting through a fluid or semi-fluid mass: the conclusion is reached that the motion of glaciers is due to viscosity and plasticity, as proposed by Forbes more than forty years ago.

SAND BOULDERS IN THE DRIFT, OR SUB-AQUEOUS ORIGIN OF THE DRIFT IN CENTRAL MISSOURI. By Prof. J. W. SPENCER, University of Missouri, Columbia, Mo.

[ABSTRACT.]

THE drift is of northern origin, as shown by internal characters. It is somewhat stratified, although this is not always easily recognized. It contains water-worn sand boulders from three to twenty feet long, which have had the forms produced when frozen. Others in all stages of fracture from ice-jams are seen.

THE COLUMBIA FORMATION. By W J McGEE, U. S. Geological Survey, Washington, D. C.

THE Columbia formation has been studied in and traced over the Middle Atlantic coastal plain. It consists (1) of a series of deltas laid down along the inland margin of the coastal plain by the Middle Atlantic slope rivers — the Roanoke, the Appomattox, the James, the South Anna, the North Anna, the Rappahannock, the Potomac, the Patuxent, the Patapsco, the Susquehanna, the Brandywine, the Schuylkill and the Delaware — during a period of submergence reaching fully 100 feet at the first named river, about 450 feet at the last named, and intermediate amounts at the intermediate rivers; and (2) of a series of terraced littoral deposits connecting and graduating into the deltas and covering the remainder of the coastal plain to the Atlantic Ocean. The deltas alike consist of a lower division made up of bowlders, coarse gravel and sand, and an upper division made up of brick-clay or loam; but this bipartition is the less definite in the littoral phase of the formation.

The formation overlies unconformably the various Cretaceous and known Tertiary deposits of the region, and has therefore been inferred to be Quaternary. Moreover, the bowlders of the lower division of the deltas are much larger than the rivers could transport in ice-floes under existing temperatures, and the loam of the upper division sometimes consists of rock-flour, or glacial mud; and it is hence inferred that the deposits were laid down during a period of cold and extensive northern glaciation.

Over considerable portions of the area of the formation, the materials of which it consists have been traced to their sources: The larger bowlders have been found to be derived from the Triassic, Palæozoic, and crystalline terranes traversed by the rivers; the smaller pebbles have been found to be generally derived from the Potomac formation; and the finer materials have been traced to several sources, including the grist of a glacier long antecedent to that which deposited the great terminal moraine already mapped most of the way across the continent. To the northward, the formation is overlain by the terminal moraine.

It has been inferred from the relation of the Columbia formation to the terminal moraine and the drift-sheet which it fringes, that the older deposit represents a period of Quaternary cold, much earlier, much longer continued, and accompanied by much greater submergence, than the epoch of cold represented by the newer deposits; and it has been inferred from the relative erosion of water-ways since the two deposits — Columbia and latest-glacial — were formed that the interval of mild climate and high level of the land between the two epochs of cold was from three to ten times as long as the post-glacial period. These inferences are fully sustained by a long series of observations extending over three years of time and many thousand square miles of area.

The results of the study of the Columbia formation and of the drift to the northward appear to form an important contribution to our knowledge of the Quaternary history of the United States: It appears to be estab-

lished that the Quaternary consisted of two epochs of cold separated by a great interval of mild climate; that the first was much the longer, though the ice-sheet did not extend so far southward along the Atlantic coast; and that while both were accompanied by depression of the land increasing northward, the depression of the first period was much the greater and extended fully three hundred miles farther southward.

GENESIS OF THE HAWAIIAN ISLANDS. By Prof. C. H. HITCHCOCK, Hanover, N. H.

[ABSTRACT.]

THESE islands constitute an archipelago, 1,725 miles long reaching to latitude 180°. There are fourteen small islands to the westward of the larger ones not usually reckoned. These are low islands, indicating apparently a greater amount of subsidence at the northwest.

The general view that the islands are of volcanic origin, situated on a plateau 16,000 feet deep, was advocated. I will particularize only that part of the paper which refers to the existence of certain terraces, supposed to be of marine origin, by Capt. C. E. Dutton in his report to the U. S. Geological Survey. He thought there were several benches largely of sedimentary materials, the highest rising to the height of 2,500 feet, upon the island of Hawaii.

1. They are spoken of rather indefinitely, as their upper levels are variable.

2. The island is everywhere covered by basaltic terraces, resulting from interruptions in the flow of lava. If these should be covered by deep soil they would resemble sea margins.

3. An examination of the butte near Hilea, figured in Dutton's report, showed it to be entirely of basalt covered by a thin sedimentary deposit, which is more or less continuous with the soil upon which the neighboring sugar plantations are located. A cut through this near Waiohinu exhibits a wonderful similarity in this deposit to the loess of the Mississippi valley. If we follow the theory of Pumpelly and regard this fine-grained deposit on Hawaii as of Eolian origin, we have probably the true explanation of its formation.

4. If of marine origin there should be coralline or other marine relics in these sediments; for these organisms are now common off the southern coast. But no evidence of this nature has yet been discovered in these terraces.

5. In the Kau desert and upon the east flanks of Mauna kea is a wide spread coating of volcanic ashes. It seems probable that these fine-grained materials furnished the substance of the supposed sediments.

6. Upon the island of Oahu and especially upon Kauai, the existence of easily decomposing alluvial-like beds, many scores of square miles in extent and of great depth, further illustrates how volcanic ejecta-menta from

monticules simulate sedimentary deposits. Cañons two hundred feet deep have been excavated in them, and the walls show lines of apparent stratification. Many of the layers have been decomposed into soft clays.

7. The changes of level upon Hawaii now observed are those of depression rather than of elevation; on its south shore the trunks of cocoanut palms are left standing in the water where they grew.

We therefore conclude that the evidence of elevation derived from these sedimentary deposits by Captain Dutton is not conclusive, and that we may still retain the views of the origin of these oceanic islands set forth by Wallace.

ON THE MONTICULIPOROID CORALS OF THE CINCINNATI GROUP WITH A CRITICAL REVISION OF THE SPECIES. By Prof. JOS. F. JAMES, Miami Univ., Oxford, Ohio, and U. P. JAMES, Cincinnati, Ohio.

[ABSTRACT.]

THIS group is a very large and diversified one and specimens are found in great abundance in the rocks of the Cincinnati Group. Only a few have worked in the field and published the results, and these are Dr. H. A. Nicholson, Mr. U. P. James and Mr. E. O. Ulrich. Dr. Nicholson has given a systematic account of forty-three species with figures, thirty-three of which have been found at Cincinnati. Mr. U. P. James has made descriptions of many species in "The Palæontologist" and Mr. Ulrich has contributed papers in the "Journal of the Cincinnati Society of Natural History. Much of the work of Dr. Nicholson and Mr. Ulrich depends upon the microscopic structure of the interior of the fossils. The present paper is an attempt to arrange them according to external features alone. The value of the exterior, though disputed by Dr. Nicholson and Mr. Ulrich, is shown to be of value and importance by quotations from their published papers, while the uncertainty of the internal microscopic features is shown by extracts in the same way.

The species are divided into six principal groups, viz., the *Massive*, *Discoid*, *Dendroid*, *Laminar*, *Encrusting* and those assuming forms of special nature.

The insufficiency and impracticability of the five subgenera of Monticulipora of Dr. Nicholson and of the eighteen genera of Mr. Ulrich is shown by a collation of the characters of each genus, and it is concluded to divide the family *Monticuliporidæ* into two genera and three subgenera, viz., *Monticulipora*, with three subgenera, *Dekayia*, *Constellaria* and *Fistulipora* and genus *Ceramopora*.

The second part contains descriptions of species with synonymy and remarks. It is to have an index to species arranged by cross references, a glossary of terms and index to the whole.[1]

[1] Part first printed in full in Jour. Cin. Soc. Nat. Hist., Oct., 1887.

THE STATE LINE SERPENTINE AND ASSOCIATED ROCKS: A PRELIMINARY NOTICE OF THE SERPENTINES OF S. E. PENNSYLVANIA. By Prof. FRED'K D. CHESTER, Delaware College, Newark, Del.

[ABSTRACT.]

AUTHOR points out on map the wide distribution of rhombic pyroxene rocks within the Azoic belt of Pennsylvania, Delaware and Maryland. Recent petrographic study has proven the genetic unity of these varied types.

The so-called Laurentian syenites, described by Mr. C. E. Hall, in Delaware and Chester Counties, Penn., are structurally united with and find their exact counterparts in the gabbros, norites and gabbro-diorites in the state of Delaware. The many areas of serpentine of southeastern Pennsylvania are closely related, if not in most respects identical, with the serpentine which is minutely described in the present paper.

The state line serpentine occurs along the boundary between Chester Co., Penn., and Cecil Co., Md. The rocks of this belt present close analogies to certain of the gabbro-diorites of Delaware, sufficient to show that they are chronologically united. The original mother rock of this belt is found as two extreme types, which run into each other by indistinct stages. The first is a crystalline mixture of bronzite and diallage with accessory olivine, magnetite, chromite and original green hornblende. In this rock feldspar is absent, or present in but a trace. The second agrees with the first, with the exception that a basic plagioclase (anorthite) is an important constituent.

The first variety mentioned is found in all stages of alteration into serpentine and talcose products, and from this source all the serpentines of this belt have been derived. Both bronzite and diallage have become altered into aggregates of colorless or light green hornblende, either tremolite or actinolite, while these in turn pass into serpentine and talc.

The second variety of the original rock shows changes identical with those observed in the Delaware gabbro-diorites. Here, as before, both varieties of pyroxene become altered into tremolite but, instead of this last passing into serpentine, we find cores of tremolitic aggregates with compact borders of green hornblende. The final product is, therefore, a compact green hornblende, whereby the original rock becomes distinctly dioritic.

This last dioritic rock is perfectly compact with scarcely visible stratification and was styled by Dr. Persifor Frazer a "trap" although it was not supposed to be related in any way to the serpentines. It is identical in field characters with a similar gabbro-diorite from Iron Hill, Del., where the rock is found in like relations to serpentine.

SOME EXAMPLES OF THE DYNAMIC METAMORPHISM OF THE ANCIENT ERUPTIVE ROCKS ON THE SOUTH SHORE OF LAKE SUPERIOR. By Dr. GEORGE H. WILLIAMS, Johns Hopkins University, Baltimore, Md.

[ABSTRACT.]

THREE years ago, at the Philadelphia meeting, the speaker had the privilege of bringing to the notice of the Association, Prof. J. Lehmann's great work on the Origin of the Crystalline Schists. In this the idea of the origin of schistose and even banded rocks by the metamorphism of eruptive masses—the prime cause being orographic or mountain-making forces—was particularly developed. Since that time this idea has constantly been receiving more and more attention, especially in Europe, and it has been fruitful in suggesting many new lines of geological inquiry. The work of Lossen, Weiss, Schmidt and Teall may be particularly mentioned. The first named of these investigators was the first to explicitly point out the peculiar fitness of eruptive rocks for the study of *Dynamic-* or, as he so aptly called it, *Dislocation-Metamorphism*. They possess a definite composition and structure which are infinitely more valuable as a starting point for the study of metamorphic changes, than the heterogeneous and variable sedimentary rocks.

This idea is not new, but it derives a new force and meaning from the aid which the microscope is now able to render in illustrating and interpreting it. Rocks are modified in three different ways when they are subjected to the action of the mountain-making forces.

1. Their external structure or morphology is changed: *Macrostructural Metamorphism*.

2. Their internal structure or histology is changed: *Microstructural Metamorphism*.

3. The nature of their component minerals is changed: *Mineralogical Metamorphism*.

Of these, the first only could be satisfactorily observed without the aid of the microscope. The third could be very imperfectly studied, while the second was quite unknown.

Macrostructural Metamorphism.

Rocks are altered

1. By stretching (Streckung) producing a banded structure as in the granulites.

2. By simple compression, producing a slaty cleavage or foliation (*e. g.*, gneiss bands foliated at an angle with their sides).

3. By compression of unequally enclosed masses, resulting in "bulging" in the direction of least resistance—jointing—"cross gashes."

4. By compression with sliding, crushing and shearing of the mass, producing schistose layers.

One of the strongest arguments in favor of the old idea of the sedimentary origin of all the schistose crystalline rock was the conformability of

their foliation. This would, however, be the same if the schistosity were produced in massive rocks by pressure. A force which elevated a system of horizontal beds would tend to develop a foliation in their included eruptives which would agree with the strike of the raised beds. Subsequent eruptions would also follow the same direction as the line of least resistance.

Example: The Marquette greenstone series and Eureka series.

At Four Foot Falls on the Menominee, the schistosity of the greenstones may be seen to agree with the slaty cleavage of adjoining sediments, NOT with their bedding.

Microstructural Metamorphism.

Admirable instances of this are continually revealed by the microscope. A few prominent examples are:

1. Quartz crystals with undulatory extinction, broken, or reduced to a fine interlacing mosaic. "Strain" twinning striæ in feldspar.

2. Feldspar crystals broken and the fragments separated. This separation is always in the same direction, no matter how the crystals may have lain.

3. Peripheral granulation ("*randliche Kataklase*") of constituents produced by a rubbing and grinding with a new crystallization in a mosaic. This produces Tönebohm's so-called "*mortar structure.*" These new products never show any pressure effects like the old.

4. Parallel arrangement of the new crystallizations in schistose rocks while the remnants of old crystals bear no relation to this arrangement. Especially seen in schistose porphyries.

Mineralogical or Chemical Metamorphism.

1. There is a direct opposition between the processes of *metamorphism* and *weathering*. One takes place at great depths and is *alteration* (change to a more, or not less crystalline form); the other is *decomposition* (hydration, carbonitization, etc., and change to a *less* crystalline and more soluble form). *Example:* chlorite and biotite. The former results from the latter at the earth's surface but it changes back to biotite by regional or contact metamorphism.

2. As examples of metamorphism may be mentioned, uralitization, saussuritization, sericitization, formation of leucoxene (sphene).

3. As a rule, chemical change is increased by and is therefore proportional to the crushing. An interesting exception to this seems to be presented by feldspar. It is freshest in the most crushed greenstones of the Menominee river, where it is most broken! Another evidence is afforded by the granite south of the Big Quinnesec Fall on the same river. This has been much pressed and has its orthoclase converted partly into kaolin, and partly into microcline, which is quite free from alteration. This indicates that the chemical and mechanical action on feldspar are *inversely* proportional. It is the reverse with pyroxene.

THE FOUR GREAT SANDSTONES OF PENNSYLVANIA. By Prof. E. W. CLAYPOLE, Akron, Ohio.

[ABSTRACT.]

THIS paper was a sequel to one that was read by the author at the meeting at Ann Arbor in 1885.[1] An attempt was then made to show that the material of the four great sandstones of Pennsylvania was derived from the quartz ledges of the South mountains, once more widely extended.

The object of this paper was to show that each of these four sandstones, the Medina, the Oriskany, the Catskill-Pocono and the Pottsville, is a record of a lost quartz ridge or reef produced by an earlier manifestation of the same tangential pressure that in post-carboniferous times produced the Appalachian arches. The site of these lost ridges was laid on the Archæan area in the east of Pennsylvania over which the pre-Cambrian strata now seen in the quartzose and schistose rocks of the South mountains may have once extended.

As a transporting force sufficient to carry and disperse over so wide an area this vast mass of sand and pebble the author suggested the tide. In the repeated wash of this forced wave every twelve hours from east to west may perhaps be found an agent capable of doing the work that was required. Possibly by this means we may explain the thinning of the material to the west and its uniform westward dispersion.

THE POTSDAM SANDSTONE IN SOUTHERN PENNSYLVANIA. By Rev. J. EDGAR, Wilson Female College, Chambersburg, Pa.

ON THE GEOLOGY OF NEW YORK CITY AND ITS ENVIRONS. By Prof. DANIEL S. MARTIN, New York, N. Y.

ON RECENT FIELD-WORK IN THE ARCHÆAN OF NORTHERN NEW JERSEY AND SOUTHEASTERN NEW YORK. By Dr. N. L. BRITTON, Columbia College, New York, N. Y.

NOTES ON THE ERUPTIVE ROCKS OF THE ARCHÆAN IN THE NEW YORK AND NEW JERSEY HIGHLANDS. By J. F. KEMP, Cornell University, Ithaca, N. Y.

THE SOUTHERN DRIFT. By JOSEPH E. WILLET, Macon, Ga.

[1] For the full text of both the papers above mentioned, see the American Naturalist for December, 1887, and January, 1888.

DESCRIPTION OF TWO CAVERNS NEAR MANITOU, COLORADO, WITH MAPS. By Rev. HORACE C. HOVEY, Bridgeport, Conn.

THE PLANTS AND FISHES OF THE TRIASSIC ROCKS OF NEW JERSEY AND THE VALLEY OF THE CONNECTICUT. By Prof. J. S. NEWBERRY, Columbia College, New York, N. Y.

THE FISHES OF THE CLEVELAND SHALE. By Prof. J. S. NEWBERRY, Columbia College, New York, N. Y.

EXHIBITION OF A NEW PETROGRAPHICAL MICROSCOPE OF AMERICAN MANUFACTURE. By Dr. GEORGE H. WILLIAMS, Johns Hopkins University, Baltimore, Maryland.

IS THERE A DIAMOND-FIELD IN KENTUCKY? By J. S. DILLER, U. S. Geological Survey, Washington, D. C., and GEORGE F. KUNZ, New York. [Published in Science.]

ON THE AGATIZED AND JASPERIZED WOOD FROM CHALCEDONY PARK, ARIZONA, WITH EXHIBITION OF MAGNIFICENT SPECIMENS. By GEORGE F. KUNZ, New York, N. Y. [Published in Popular Science Monthly.]

ON THE DIAMOND FOUND AT DYSARTVILLE, N. C., AND ON ROCK-CRYSTAL FROM ASHE CO., N. C. By GEORGE F. KUNZ, New York, N. Y. [Published in Amer. Journ. Science.]

THE RELATION OF THE POLE OF THE LAND-HEMISPHERE TO CONTINENTS, TO THE MAGNETIC SYSTEM, AND TO SEISMIC FORCE. By Prof. RICHARD OWEN, New Harmony, Indiana.

RELATION BETWEEN GEOGRAPHICAL FORMS AND GEOLOGICAL FORMATIONS. By Prof. RICHARD OWEN, New Harmony, Ind.

THE "SLATE CONGLOMERATE" OF THE ORIGINAL HURONIAN, THE PARALLEL OF THE OGISHKE CONGLOMERATE OF MINNESOTA. By Prof. N. H. WINCHELL, Minneapolis, Minn.

THE ANIMIKIE BLACK SLATE AND QUARTZYTE AND THE OGISHKE CONGLOMERATE OF MINNESOTA, THE EQUIVALENT OF THE ORIGINAL HURONIAN. By Prof. N. H. WINCHELL, Minneapolis, Minn.

AN UNCONFORMABLE CONGLOMERATE LYING ON THE MARQUETTE IRON-ORE ROCKS AT NEGAUNEE AND ISHPEMING, MICHIGAN. By Prof. N. H. WINCHELL, Minneapolis, Minn.

A GEOLOGICAL SECTION AT GREAT BARRINGTON, MASS. By Dr. ALEXIS A. JULIEN, Columbia College, New York, N. Y.

THE HURONIAN SYSTEM. By Prof. ALEXANDER WINCHELL, Ann Arbor, Michigan.

THE ORIGIN OF THE TERRACES ALONG THE OHIO RIVER BETWEEN CINCINNATI AND LOUISVILLE. By Prof. JOHN C. BRANNER, State Geologist of Arkansas, Little Rock, Ark.

THE SOUTHERN LIMIT OF THE GLACIAL DRIFT IN KENTUCKY AND INDIANA. By Prof. JOHN C. BRANNER, State Geologist of Arkansas, Little Rock, Arkansas.

THE TRENTON LIMESTONE AS A SOURCE OF PETROLEUM AND INFLAMMABLE GAS IN OHIO AND INDIANA. By Prof. EDWARD ORTON, Columbus, O.

THE UNKNOWN GEOLOGY OF ILLINOIS. By Dr. THEODORE B. COMSTOCK, Champaign, Ill.

NOTES ON THE EXTINCT THERMAL SPRINGS OF ARKANSAS. By Dr. THEO. B. COMSTOCK, Geological Survey of Arkansas, Little Rock, Ark.

EXHIBITION OF PHOTOGRAPHS OF THE INTERIOR OF A COAL MINE. By FRED. P. DEWEY, Smithsonian Institute, Washington, D. C.

ON THE AGE OF THE LIMESTONES OF WESTCHESTER AND NEW YORK COUNTIES. By Dr. FREDERICK J. MERRILL, Columbia College, N. Y.

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ADDRESS

BY

PROF. WILLIAM G. FARLOW,

VICE PRESIDENT, SECTION F.

VEGETABLE PARASITES AND EVOLUTION.

In the countless discussions concerning evolution which have followed the publication of Darwin's Origin of Species, zoölogists have gone farther than botanists in their efforts to explain the possible origin of higher forms from the lower. Botanists, as a rule, have contented themselves with a consideration of the ancestral relations of the orders of higher plants but, until very recently, they have scarcely made any serious attempt to present a general scheme showing, from an evolutionary point of view, the relations of all the groups of the vegetable kingdom. This may be due either to their timidity—perhaps modesty is a better sounding word—or to their ignorance. If the latter, they have certainly been wise in avoiding unnecessary display of their ignorance; if the former, they can easily be pardoned, when one considers how large a part an aggressive audacity savoring of sensationalism has played in the formation of some schemes of development.

On abstract grounds alone, I presume that few botanists would object to the statement that all plants have been developed from simple ancestral forms, which were nearly related to some of the lower animals; but, when it comes to saying in anything like a definite way that certain existing forms have arisen from other lower existing forms or their immediate allies in some past epoch, and so on until the lowest form is reached, botanists may well insist that imagination should not be allowed too large a scope in supplying missing links. It is precisely in this point that zoölogists have an advantage over botanists. The palæon-

tological record of lower animals is more complete than that of lower plants so that, where the zoölogist might reasonably form an hypothesis, the botanist must rely more on his imagination until, in the end, he finds himself in the possession of a chain composed to a considerable extent of missing links. As it is, if we would consider the evolution of plants, not getting much light on the progress of the lower forms from palæontology, we are compelled to trust largely to plants as we now find them and to ask what are the inferences which we are permitted to draw from existing structures and conditions. I shall not attempt to offer any scheme of development, or to sketch a family tree whose roots are *Protococci* and bacteria and whose ripe apples are the genera of Phænogams, but shall restrict myself to some considerations concerning vegetable parasites and the inferences as to their possible origin which may be gathered from what we already know of their structure and habits; partly because this is a group of plants in which I am especially interested, and partly because the problems which they offer, even if they can not be solved at the present day, are, at least, full of suggestions.

In the first place, a word as to the different kinds of plants which are included among parasites. A parasite is usually defined as a plant which is unable to transform inorganic material into organic compounds and which is consequently obliged to obtain its organized materials from other plants or from animals. The definition, in general, is an accurate one and correctly defines the vast majority of vegetable parasites which belong to the class of fungi. That they are strictly dependent on the organized materials derived eventually from other plants or animals is sufficiently evident when we consider that fungi are destitute of chlorophyll, the necessary agent in the assimilation of inorganic material. Of the parasites proper, we have two kinds: the saprophytes, which live on dead or inert matter; and the special, or true, parasites as they are usually called, which can only grow on the tissues of living plants or animals. Whether the line between saprophytes and true parasites is sharply defined is a point which need not at present be discussed. It is enough to say that, as a rule, saprophytes grow more or less indiscriminately on dead organic substances, while the true parasites are generally limited to a single species of plants or to the species of a single genus or order. It is almost unnecessary to cite instances of the two kinds of parasites

proper since you will at once call to mind *Penicillium* and other common moulds which grow as saprophytes on an endless variety of substances; while we have as illustrations of true parasites the grape *Peronospora* which grows abundantly on species of *Vitis* and is occasionally found on *Ampelopsis* and *Cissus*, both genera of *Vitaceæ*, and the potato-rot fungus sometimes found on the tomato which belongs to the same order as the potato, and rarely on species of *Scrophulariaceæ*, a nearly related order.

The proper parasites do not exclusively belong to the class of fungi. You are familiar with the Indian pipe (*Monotropa*) and dodder (*Cuscuta*) which are our common representatives of parasites that are found in a comparatively small number of orders of Phænogams. As chlorophyll is wanting in these plants we are forced to assume that the parasitism is as complete as in fungi. You, also, will recall the mistletoes and the *Gerardias*, together with other members of the *Scrophulariaceæ* which are not proper parasites in the sense in which we have already spoken, but may rather be called partial parasites; because, while they have chlorophyll and are to a certain extent able to transform inorganic into organic material, they still depend in part on material taken from other plants to which they are more or less closely attached. In the discussion of the evolution of parasites, the phænogamic parasites, however, are of comparatively little importance; because, by means of their flowers and fruit, they are rightly classed as belonging to, or closely related to, well recognized orders of Phænogams and the question of the origin of the parasites themselves is not to be separated from the question of the origin of Phænogams as a whole, so that, in this case, we have only to account for the modification of the organs of vegetation whose greater simplicity may be explained by the loss of leaves and other assimilating organs which have become unnecessary to plants that have acquired the power of living upon the food assimilated by other plants. In short, as far as parasitic Phænogams are concerned, they may be regarded as degenerate forms of other Phænogams for, in a plant, the inability to assimilate inorganic material should be regarded as a degraded condition in which the chances of survival are diminished unless some extraordinary provision is made for reproduction, which is not the case in Phænogams, whatever may be true of fungi.

Whether any proper parasites are to be found among algæ is a question on which there is a difference of opinion. For my own

part, I am unable to recognize any proper parasite among algæ, although it is tolerably certain that a number of forms generally classed among algæ may be regarded as partial parasites. This point, however, can be better considered later on.

Let us next briefly consider the mutual relations which exist between parasites and their hosts, that is, the substances, dead or living, on which they are growing. At first sight a parasite would seem to be purely destructive in its action and that this is really the case is evident in the great majority of instances. When a piece of bread is attacked by the mould, *Mucor stolonifer*, its substance continually diminishes with the growth of the mould. We need not stop to consider the saprophytes for the case of the true parasites is still stronger. There is a constant struggle between the rots, rusts and other true parasites and the hosts on which they are growing. Just so far as the fungus flourishes, so does the host suffer and, if the conditions of temperature and moisture are favorable to the fungus, the host may be quite destroyed. If the conditions are not favorable to the fungus, the host may continue to grow and the fungus may gradually disappear or, at least, pass into a quiescent state. An instance of the sudden and complete destruction of the host is seen in the case of the bad epidemics of the potato-rot when whole acres suddenly rot and die. This is an extreme case. Other members of the *Peronosporeæ* attack young seedlings some of which are destroyed while others continue to grow and may be said to throw off the fungus. From cases of the complete and sudden destruction of the host, either in its mature or seedling condition, we pass to parasites which are less virulent and whose action is more local. We have all grades of injury done to the host from destruction of the leaves and consequent diminution of the assimilating power, which may entail serious or fatal results; from the formation of circumscribed knots and tumors, which may cause destruction of the branches and, in course of years, the death of the plant; from fungi, which attack the flowers or fruit and cause diminished reproductivity without injury to the vegetative powers, down to the insignificant distortions of scattered epidermal cells caused by *Synchytria*. But in all these cases the action of the parasite is destructive. We cannot conceive that it is of the slightest benefit to the host. It robs the plant of the food which it needs for itself and gives back nothing good in return.

We have, on the other hand, instances of parasitism in which it

is claimed that the relation of parasite and host is one of mutual benefit. To this condition the name symbiosis[1] has been applied. The two most marked instances of symbiosis among plants are to be found in lichens and the fungus-growth first called, by Frank, *Mycorhiza.*

The thallus of lichens, you will bear in mind, is composed of two elements: the green cells or filaments called gonidia, and the colorless threads or hyphæ. Any extended discussion of the algo-fungal theory of lichens would be out of place on the present occasion, and it is only necessary to say that I do not see why we may not consider the gonidia, to be what they appear to be, viz., algæ; and the hyphæ, fungi parasitic on the gonidia. Certainly, the opponents of the algo-fungal theory, in spite of all their attempts, have not, as yet, given satisfactory proof that the gonidia are produced from the hyphæ or the hyphæ from the gonidia, so that we are forced to regard them as two distinct entities. The strong point of the opponents of the algo-fungal theory has been that, if it is true that what is called a lichen is really a fungus parasitic on an alga, it is inconceivable that the alga should not be injured or even destroyed by the fungus. It is certainly a fact that the gonidia, or algæ, are not destroyed, and it has been assumed by both the advocates and opponents of the theory that the gonidia are not injured by the growth of the hyphæ, while some even go so far as to say that their growth is aided thereby. To account for this state of things, the advocates of the theory have advanced the view that, in lichens, we have a sort of mutual parasitism, and the statement has been made that "the hyphæ lie on the gonidia and carry to them crude nutritive fluids in return for which they receive a part of the assimilated material in the gonidia." But what good the gonidia can derive by having crude material brought to them by the hyphæ, if they must give back a part of the assimilated material to them, is not clear since it is a well-known fact that the gonidia can and very often do live and flourish in a free condition and are amply able to obtain all the nourishment they

[1] The word symbiosis was originally applied to all cases where different organisms were associated together in a community, and, in this sense, included the true parasites. The application has gradually been modified until, at the present day, symbiosis is generally understood to mean the association of plants with plants or plants with animals in such a way that the relation between them is one of mutual benefit, or in which there is at least, no injurious action of one organism on the other. In this sense, as contrasted with true parasitism, the word is here used.

need without the help of the hyphæ and, at the same time, can use for their own exclusive benefit all the assimilated material. On the other hand, it is known that the hyphæ are dependent on the gonidia for their development. The advantage to the gonidia is quite hypothetical. The advantage to the hyphæ is real, and it is, to speak mildly, a bad case of what the French call *un œuf pour un bœuf.*

The alleged proof that the gonidia are benefited by contact with the hyphæ rests on laboratory cultures in which it is claimed that, if the germinating spores of lichens be brought in contact with pure gonidia, the hyphæ at once grow more rapidly, and the gonidia also begin to multiply. But this increase of the gonidia is not necessarily a sign that the conditions of growth have become more favorable. When the black-knot fungus attacks a branch of a plum tree the parenchymatous cells increase, and a knot is formed and the same thing occurs when branches of red-cedar are attacked by *Gymnosporangium macropus.* Here, the increased growth does not indicate an increased supply of food, but an irritation caused by a noxious parasite. The increased growth of normal cells in the presence of irritating foreign bodies is well known to both animal and vegetable pathologists and is not interpreted by them to mean an improved condition, but rather an attempt to get rid of something harmful. The same explanation may be given to the lichen cultures. But cultures on microscopic slides in the laboratory surely should not be regarded as more conclusive than what is seen on a much larger scale in nature. One has only to compare the *Chroolepus*—forms which constitute the gonidia of *Opegrapha*, with the same forms when free from the hyphæ of the *Opegrapha*, to be convinced that they grow and fructify decidedly better when free than when shut up in the lichen-thallus. They are neither benefited nor destroyed, but they are weakened and injured. The same is true of the cystococcoid or protococcoid gonidia of the larger lichens which are more luxuriant when growing free on rocks and bark. It is impossible to regard the *Stigonema* gonidia, distorted and broken up by the hyphæ, as in a more flourishing condition than when free.

It seems to me that the real error of the supporters of the algo-fungal theory is not that they assume that the gonidia, the algæ, can support themselves and the hyphæ too, but that they assume that they are not injured thereby. In their attempt to show how

a possible advantage to the gonidia might arise, they have not sufficiently regarded the palpably injurious action of the hyphæ. From the facts which I have given it is plain that they are injured and, if the injury is less than in most cases of parasitism — which may be due to the fact that the hyphæ of lichens grow more slowly than those of other fungi — it is nevertheless an injury, and we must recognize in lichens not a case of symbiosis or mutual parasitism, but a case of true parasitism with a minimum of injury to the host. In view of the facts, one can be an advocate of the algo-fungal theory without believing that there is a double parasitism.

In 1885,[2] Frank announced the following discovery: that certain species of trees, especially *Cupuliferæ*, do not regularly obtain their food directly from the soil but their roots are connected with the mycelium of a fungus by whose agency all the nourishment is transferred from the soil to the tree. He called this condition *Mycorhiza* and described the fungus as intimately united with the inner cortex of the roots just back of the tips and forming a felt-like cap over the tips. He maintained that this union of mycelium and roots was of constant occurrence in the *Cupuliferæ* which he had examined, oaks, beeches, chestnuts, hazel-nuts and hornbeams, and more or less constant in *Salicaceæ* and *Coniferæ*. At a later date[3] he went further and stated that the *Mycorhiza* is a symbiotic condition which may perhaps be found in all trees under certain conditions; that it is found only where the soil consists of humus or undecomposed plant remains; that the fungus of the *Mycorhiza* conveys to the tree not only the necessary water and the mineral constituents of the soil but, also, the organic material derived directly from the humus and decomposing vegetable matter; and that it is through the agency of the fungus alone that the tree obtains its food from the soil. If one could accept without reserve, the conclusions of Frank, we have in *Mycorhiza* a clear case of symbiosis in which a fungus which lives as a saprophyte on vegetable mould is intimately united with the tissues of Phænogams on which it acts, not as a parasite but as a conveyer of nourishment. Unfortunately, the statements of Frank are, to a great extent, not confirmed by other competent observers. R. Hartig has shown[4] that the *Mycorhiza* condition is not at all

[2]Ber. Deutsch Bot. Ges. III, 128. [3]l. c., III, XXVII.
[4]Bot. Centralblatt, XXV, 350.

necessary to the nourishment of trees even in *Cupuliferæ*, since he finds that, in many cases, roots of healthy trees are quite free from *Mycorhiza* and, even in trees where there is a marked *Mycorhiza* of some roots, there are others quite free from it. He regards *Mycorhiza* not as a case of symbiosis comparable to that of lichens, as does Frank, but rather a case of proper parasitism, and Kamienski[5] states that, in the cases of *Mycorhiza* of trees which he has examined, he has always found evidences of injury done to the roots by the fungus which he also regards as a parasite of a destructive nature. P. E. Mueller, to a certain extent, endorses Frank's views, as far as the *Mycorhiza* of beeches is concerned.

We are, on the whole, warranted in believing that the *Mycorhiza* condition is rather a condition of proper parasitism than of symbiosis in the case of trees. We still have the case of *Monotropa Hypopitys*, a small ericaceous parasite, in which Kamienski showed, as early as 1881, that the roots are surrounded by a mycelium which, however, does not penetrate into the substance of the roots, as in the *Mycorhiza* of Frank. He considered that the fungus, in this case, was the medium of transfer of nourishment to the *Monotropa* and did not agree with the then prevailing view that *Monotropa* itself was directly parasitic on the roots of other plants. We may safely consider that there is a symbiosis in *Monotropa Hypopitys* and further investigation may show a similar condition in some other closely related phænogamous plants which are destitute of chlorophyll, but here the case is very different from that of the large trees, abundantly provided with assimilating organs of their own in which, if there is symbiosis at all, it certainly does not exist on the wholesale scale which Frank claims.

With regard to the symbiosis of plants and animals I will say but a word, for the subject is one which pertains to the domain of the zoölogist rather than to that of the botanist. The inherent objections against the probability that plants and animals should live in a state of symbiosis are less than in the case of symbiosis in the vegetable kingdom; because, in the former case, the plants in question belong not to the group of fungi but are algæ possessing chlorophyll, or a modified form of chlorophyll. The symbiotic alga could support itself; the animal, on the other hand, could support itself and, bearing in mind the different products of as-

[5] Bot. Centralblatt, XXX, 2.

similation and respiration in plants and animals, one could easily conceive that benefit might arise from the combination of the two. Whether the combination really exists in many cases is not yet certain, because it too frequently happens that zoölogists do not agree as to whether the assumed alga is really an alga or a proper organ of the animal itself. It becomes a question of authority and a botanist is not in a condition to estimate the comparative merits of observations made by zoölogists. As far as I am at liberty to form any opinion at all, I should say that zoölogists were inclined to accept, at least, a mechanical symbiosis of unicellular-algæ and animals in a considerable number of instances. Whether the symbiosis is physiological, as well as mechanical, is a point on which more light is apparently needed.

The symbiosis of plants and animals is, perhaps, better to be compared with that of *Nostocs* with *Hepaticæ* and *Azolla* than with the condition which exists in lichens. Some of the recorded cases show clearly a mechanical symbiosis even if others be regarded as merely accidental and temporary unions of different organisms. Whether the symbiosis here is physiologically of advantage to the nutrition of both organisms is doubtful. The *Nostocs* are certainly not injured and they may derive benefit from the shelter afforded. It will not do to go too far in this direction, however, because we should at length be forced to speak of symbiosis in cases where *Nostocs* grow in crevices of rocks, which would be absurd.

I have dwelt somewhat at length on the subject of symbiosis because, as it seems to me, botanists have gone too far in assuming a beneficial action of the parasite on the host in many cases where not only no direct benefit can be proved to exist but where a closer examination shows that an injury is really done, although it may be slight. In short, symbiosis as distinct from true destructive parasitism is not the comparatively common condition in the vegetable kingdom which it is generally supposed to be by those whose opinion is worth considering, for we need not regard those writers who, seeing in symbiosis a charming instance of domestic felicity and concord with which they can point a moral and adorn a tale, have given to the public essays whose only proper place is on the shelves of a Sunday School library. Accepting the existence of symbiosis where both members are chlorophyll-bearing plants, we must still believe that, with rare exceptions, the cases where one member is a fungus should be referred rather to

the class of true parasites in which the advantage is altogether on one side.

If we turn now to the question of the origin of vegetable parasites we find ourselves in a dilemma. Certainly, the parasites could not have originated before the plants and animals on whose remains or in whose tissues they live. On the other hand, accepting the law of evolution, that the more complex forms are developed later than the simpler forms, the parasites must have preceded the forms on which they prey. The paradox is, however, more in words than in reality. We can only suppose that our present parasites have existed from early times but were not always parasites. The question might arise here, What do we mean by higher and lower forms? The terms are elastic and one sometimes suspects that they have been stretched and twisted to suit the necessities of individual writers. It is not quite plain, for instance, why we should say that the giant kelp of the Pacific, *Macrocystis pyrifera*, with its branching stems several hundred feet long furnished with innumerable leaves and air-bladders, is less highly organized than the small frondose hepatics, like *Riccia*, or such mosses as *Phascum*. There is one point on which all botanists would probably agree in speaking of high or low organizations, viz.: that complications of the reproductive apparatus indicate a high organization, however simple the vegetative organs may be, and that, as we advance higher in the scale, we find more and more numerous embryonic conditions which represent free conditions of less highly organized plants.

Throwing out of consideration the phænogamous parasites for the reasons previously given, there is no doubt that the immense majority of vegetable parasites belong low down in the scale of development and we can infer from the simplicity of their reproduction that they originated at an early period. Other things also point in the same direction. In the class of fungi, although the sexual reproduction is of low grade, it embraces a number of different types and, as far as non-sexual modes of propagation are concerned, although it may be said that they only indicate an effort on the part of the plants to adapt themselves to peculiar conditions, fungi are far better provided than any other plants. We are, perhaps, at liberty to suppose a remote origin from the large number of species of fungi now in existence and, in this connection, a few statistics may prove of interest. The question is frequently asked whether the species of fungi are more numerous than those of

Phænogams. It is safe to suppose that they are, although it is not true that more species of fungi have already been described. The systematic study of fungi in Europe and North America is of so much more recent date than the study of the Phænogams of those two continents, while the fungi of a large share of the earth have scarcely been studied at all, that a comparison of the described species of the two classes fails to give a correct estimate of the real numbers.

The reason for supposing that the species of fungi are more numerous than those of Phænogams is founded on the fact that, in countries whose fungal flora has been most thoroughly studied, we find few species of Phænogams which are not already known to be attacked by some special parasite while the majority of species serve as hosts for a considerable number of species of fungi. A few figures will show this point clearly. In his treatise on the fungi which attack the species of *Vitis*, published in 1879, Pirotta enumerates one hundred and four species of parasites. Between ten and twenty of these are fungi not found on *Vitis* alone but this number is more than counterbalanced by species peculiar to *Vitis* which have been described since 1879. It may be objected that some of the forms called species by Pirotta are probably merely stages of some of the other species enumerated. Admitting that this is possible and even probable, if we deduct half, or even two-thirds which is liberal to the last degree, we still have thirty to fifty species of fungi at the lowest estimate, which are peculiar to six species of *Vitis*, the number of species of the genus included in Pirotta's observations. I have little doubt that the real number of species of fungi peculiar to the genus *Vitis* is much larger than the estimate I have just given. If the relative number of species known to occur on *Vitis* is greater than that of those known most on other genera it is due rather to the fact that, from their importance in horticulture, they have been more carefully studied than because other genera are less frequented by special fungi.

The province of Venetia is probably no richer in fungi than other parts of the world but, as it is of small size and is the residence of a considerable number of mycologists, its flora has been more thoroughly studied than that of this country and we can obtain a more accurate view if we examine statistics of the Venetian flora. Cuboni and Mancini enumerate sixty-five species of fungi which occur on the chestnut and over three hundred species on *Quercus*,

including three native species of that genus. If we deduct a large number for species which are not found exclusively on these two genera or which are merely secondary forms of other species, we still have a considerable number of fungi to a small number of Phænogams. Turning to the American flora, we find that the species of a genus as erratic as *Sarracenia* are not without their proper parasites, for on four species of *Sarracenia* we already know four species of fungi, three of which are peculiar to the genus. The list of fungi which grow on oaks in the United States includes between five hundred and six hundred species. The greater part however are not peculiar to oaks and, as the synonymy of the species is much confused, the exact number of fungi known on all our oaks cannot be given exactly. On *Quercus alba* fifty-seven and on *Q. tinctoria* forty-six species are reported, about a quarter or possibly a third of which are probably peculiar to those species.

We can start with the postulate that vegetable parasites must have originated at an early epoch and must have been derived from non-parasitic forms. What forms? Here we enter upon the field of pure speculation. It can hardly be supposed that we shall ever know what was the earliest form of life. It may have been some protoplasmic structure which was neither strictly vegetable nor animal. Probably the earliest forms of undoubted plants were unicellular forms like *Protococcus*. The term *Protococcus*, as used at the present day, includes some forms which are claimed by zoölogists; whether rightly or wrongly is a question which need not concern us for some *Protococci* are certainly plants. The *Protococci* are simple green cells which multiply by division into two, and so on, and which, at times, also produce in their interior zoöspores which escape and form new individuals.

How other chlorophyll-bearing plants might have arisen from *Protococci* we cannot stop to consider, and we can only touch upon the possible origin of the colorless parasites. A vegetation, consisting of simple forms like *Protococci*, once established, there is no reason why there might not quickly have followed parasites of the order *Chytridiaceæ*, the species of which abound at the present day in both salt and fresh water. The simple forms of the order consist of colorless cells which produce in their interior colorless zoöspores, which escape and attach themselves to submerged plants and animals.

The step from *Protococcus* to *Chytridium* is slight. We have

only to suppose that a *Protococcus* has acquired the power of attaching itself to other *Protococci* or to low animals and has gradually lost the chlorophyll which is no longer of service to a plant in a position to absorb nourishment directly from living organisms. Other natural changes would be the development of processes for attaching the *Chytridium* to the host or for enabling it to penetrate the walls of the host so that the parasite could make its way into the interior. In short, it is probable that, at a very early epoch, true parasites existed essentially like our present *Chytridia*. If the first plants were marine, it is altogether likely that the first parasites were *Chytridia*, if we can judge by present conditions. In the present age comparatively few species of fungi grow in salt water. The few that we have belong principally to the *Chytridiaceæ* and are abundant enough on the marine algæ of all groups. Most of the other marine fungi are forms like *Leptothrix* which may rather be regarded as degenerate forms of *Nostocs* or *Schizophyceæ* than as forms derived from anything like *Protococcus* or *Chytridium*. It is certainly true that there are very few species of fungi higher than *Chytridium* or *Leptothrix*, if one can call *Leptothrix* a fungus, found on strictly marine plants. There are a few, however, and on the New England coast the stipes of the digitate *Laminariæ*, while yet submerged, are attacked by a species of *Sphærella* belonging to the *Pyrenomycetes*.

Whether the filamentous and higher forms of parasites have been derived from the simple *Chytridia* is not easy to surmise. Among existing *Chytridiaceæ* we have a series of genera in some of which there are simple rhizoids, and in others, like *Cladochytrium*, a well-developed mycelium. Furthermore, the species of, at least, three *Cladochytria* have lost the aquatic habit and live in the tissues of *Iris*, *Menyanthes* and *Sanicula*. In *Polyphagus*, Nowakowski has also observed a conjugation of the mycelium of two individuals. Admitting the fugitive character of the mycelium of *Chytridiaceæ*, there is still no reason why the filamentous fungi might not have developed from species of this order. The zoöspore-bearing cells, as the parasite lost its aquatic habit and became aerial, might naturally be transformed into sporangia with non-motile spores, like those of *Mucor*, and, as it acquired the power of growing in solid tissues, one of the conjugating cells would advantageously be developed into a pollinodium, and we should then find oösporic forms. But it is hardly worth while continuing the chain of possibilities further in this direction.

As I have said, it seems to me not unreasonable to suppose that true parasites may have originated at a very remote period primarily from non-parasitic plants. But we must also consider another question. Is it not more probable that saprophytes were first developed and from them arose the true parasites? The line between saprophytes and true parasites is not well defined among existing plants. Some species might, with sufficiently good reason, be placed in either class, for what are called by Van Tieghem facultative parasites may live ordinarily as saprophytes and yet at times live a truly parasitic existence. The great majority of fungi are saprophytes, and De Bary has shown[6] in an instructive way how *Peziza sclerotiorum*, during a part of its existence, is a saprophyte and becomes later a true parasite. The germinating spores will not penetrate the living cells of the carrot on which the mature forms of the fungus is found, but live a saprophytic existence for some time. After they have attained a certain growth and strength they are then able to make their way into the carrot which they destroy. The mechanism is as follows: after a certain time the saprophytic hyphæ excrete an oxalate which is able to destroy the superficial cells of the carrot with which the hyphæ may come in contact, and the fungus then makes its way into the plant. It is probable that a considerable number of saprophytes may act in the same way as *Peziza sclerotiorum*, and it is not impossible that a good many existing saprophytes are developing into parasites, and, if the present state of things correctly represent what has always been going on, it would lead us to believe that the saprophytes first came into existence and the parasites followed. Since actual knowledge is out of the question, one can take either theory without denying the other *in toto*. The probabilities seem to me to favor the origin of *Chytridia* from *Protococci*, if we regard the morphological rather than the physiological side of the question. How far the first *Chytridia* were true parasites rather than saprophytes may be questioned. Decidedly the majority of the living species, I should say, are parasites, but in some the parasitism is not well-marked, and they may be conveniently called epiphytic.

Still another possibility must be considered. May we not suppose that the first living beings were protoplasmic bodies, neither plants nor animals, or both, if you please, and from them parasitic and

[6] Bot. Zeit., 1886.

non-parasitic plants were simultaneously developed? Orders like *Myxomycetes* might perhaps lead us to suppose that this view was the true one. But it may be assuming too much to suppose that *Myxomycetes* are plants at all. If they are plants, they have remained in a low condition and have no offshoots represented by higher forms of plants. There appears to be only one way to find out whether a given structure is a plant or an animal, and that is to see whether it is described in zoölogical or botanical manuals. Unfortunately, this does not help us in the case of the *Myxomycetes*. We can safely say, however, that the more highly developed parasites have not been developed from *Myxomycetes*, and there is very little to lead us to believe that parasitic and non-parasitic plants were simultaneously developed from primitive protoplasmic structures.

It has already been stated that phænogamic parasites should be regarded as degenerate forms of other Phænogams. Their line of development is not through the parasites of the class of fungi. If one is willing to believe that the first parasites were *Chytridiaceæ*, or something very much like them, from which it is possible some of the filamentous zygosporic and oösporic fungi have been gradually developed, he is not, however, forced to believe that such a course of development is probable as well as possible. The class of fungi is not a homogeneous one. It is rather an assemblage of forms which have certain common physiological resemblances but marked morphological differences. When one regards fungi as a single class of plants and attempts to trace a clear connection between the highest and lowest members he finds numerous gaps which cannot well be filled. A general parallelism, however, exists between chlorophyll-bearing algæ and fungi, and one is forced to ask whether the order of development has not been from the lowest to the highest algæ—the class of algæ being more homogeneous than that of fungi—and whether the fungi have not arisen not from any one primitive group of algæ but from different groups of algæ at different periods in the progress from below upward.

This view seems to be more in accord with existing facts than any other and brings phænogamic parasites into harmony with the rest. If the phænogamic parasites may be regarded as derived directly from other *Phænogams*, so *Chytridiaceæ* may be supposed to be derived from *Protococcaceæ*. It may be that some of the zygosporic and oösporic fungi have come from the ultimate devel-

opment of *Chytridiaceæ* but it is more natural to suppose that the greater part of them are direct derivatives of zygosporic and oösporic algæ. Special applications of this theory would lead to so many technical details, that they must be omitted on the present occasion. In general, if the theory is accepted, we should expect that the fungi first derived from any group of algæ would exhibit the characteristic modes of reproduction. In the sexual reproduction both groups are much alike and, if there are fungi at the present day whose reproduction is different from that of any algæ, it is because the reproduction has assumed more and more a non-sexual character until, as in some groups of what are called higher fungi, sexuality has quite disappeared, as is supposed to be the case in *Basidiomycetes*. It is sometimes said that non-sexual modes of reproduction always precede the sexual. This is true only to a certain extent. It may be true, for instance that, in the earliest forms which had zoöspores, the zoöspores were at first non-sexual and afterwards acquired the power of conjugating. But in fungi, where we have more non-sexual forms of reproduction than anywhere else, they must, in most cases, be regarded as secondary and degraded, not primary forms.

Fungi are plants which depart more and more from what we may call typical plants. When we speak of higher plants we mean those in which the organs of assimilation and sexual reproduction exhibit a high degree of differentiation. When we speak of higher fungi, however, we refer to forms in which the vegetative organs are represented merely by a system of colorless threads and in which the sexual reproduction is seldom well marked, if it exists at all, and they can be called high only in the sense that their numerous and often complicated modes of non-sexual reproduction are better developed than in what are called the lower fungi. In the struggle for existence among the higher plants those succeed best which are best able to assimilate crude material in the growing season and have the largest provision of seeds and reservoirs of assimilated food to carry them over the season of rest. In the struggle for existence among fungi, although there is an advantage if the mycelium is able to assume an indurated condition, like the sclerotia, at seasons unfavorable for growth, it is of much greater importance that there should be a variety of reproductive bodies some of which, at least, are light and easily transported while others are denser and better able to endure extremes of tem-

perature and moisture so that the fungus may be able to take advantage of any chance which may arise should the proper host be present. How well they are able to take advantage of temporary favorable conditions is shown in the rapid spread of epidemic diseases caused by fungi.

But it is better not to pursue the subject further. What I have already said will, I fear, appear to you too vague and uncertain, for the balancing of possibilities, although pardonable in philosophy, should not be carried too far in natural science. Of course no celebration of our national anniversary is complete without a balloon ascension, and the more gas the better, provided the aeronaut, or as the papers generally call him, the professor, only lands safely. So our Society sends up its annual balloons in the shape of addresses in which the professors are allowed to soar above, though not out of sight of facts. But they must not remain too long up in the air and the gas for their balloons should be generated in the laboratory of experience and study. In their every-day work, it seems to me that the attitude of botanists, at the present day, is the correct one. Following the prevailing tendency in business affairs the question they ask of plants is not so much, "Who is your father and where did you come from?" as "What can you do?"

PAPERS READ.

REMARKS ON CLASSIFICATION. By Prof. BURT G. WILDER, Ithaca, N. Y.

[ABSTRACT[1]].

THE accompanying arrangement of the Metazoa up to the mammalia is partial and mostly provisional. It is wholly dichotomous. All the divisions are based upon the conditions of the cavity of the central nervous system. The names are largely correlated and refer to characters which are constant and peculiar.[2]

Two-fold divisions are not uncommon but, so far as known to the writer, dichotomy has not been distinctly recognized as a fundamental principle in natural classification. Polychotomy is probably always provisional and not wholly natural.

The superior taxonomic value of the brain and heart was insisted upon by the writer in 1875;[3] more recently he has been impressed with the profound morphological significance of the *neurocœle* or cavity of the central nervous system. This cavity persists in all ordinary vertebrates and in Branchiostoma and exists in the early stages of Tunicates. It has not been observed in any other "Invertebrates" excepting, perhaps, *Balanoglossus* (Bateson). The "Invertebrates," then, are *Stereoneura*, while the former are *Cœloneura*, this being equivalent to Chordata.

The writer cares less for the adoption of *Cœloneura* and *Stereoneura* than for the admission that soft parts are not only physiologically but morphologically more significant than hard; that the neuron (cerebro-spinal axis) is more important than the axon (skeletal axis); and that the cavity of the one is a more substantial basis for the primary subdivision of the Metazoa than is the entire mass of the other.

Perhaps the first division, however, should be into those in which distinct nervous centres have been found (Neurica) and those in which they have not (Aneurica).

If the name *Vertebrata* is retained, there should be an understanding as to whether it shall exclude Branchiostoma or include it, or include the Tunicates as well.

[1] The paper has been published in the American Naturalist, October, 1887, pp. 914–917.

[2] On this point see the writer's "Educational Museums of Vertebrates," Amer. Assoc. Proc., 1885, p. 276.

[3] The brains of Ganoids; Amer. Assoc. Proc., 1875, p. 189.

Among the Megaulica the Ganoids and Teleosts constitute "fishes" or Pisces. In the former, the olfactory ventricles are considerable; in the latter absent or insignificant.

The idea of dividing the Metazoa according to the presence or absence of the neurocœle was first recorded by the writer on November 27, 1883; the words *Stereoneura* and *Cœloneura* are dated April 3, 1885; F. Jeffry Bell's commentary on the cavity of the cerebro-spinal axis of Chordata was first seen March 18, 1886; in January of that year, in lectures to students and in a letter to Prof. J. H. Comstock, a general scheme of dichotomous classification was presented in substantially the form here given.

Sauropsida = reptiles + birds; mesocœle laterally extended; root bilobate.	*Mammalia*, mesocœle tubular; mesocœlian roof quadrilobate.
Anamniota = branchiata = Amphibia + Dipnoi; aulic floor approximately horizontal.	*Amniota* = abranchiata; aulic floor approximately vertical; Reptiles, Birds, Mammals.
Megaulica (aula large); cerebral hemispheres extended horizontally, or undifferentiated; = Ichthyopsida — Amphibia, Dipnoi and Branchiostoma.	*Micraulica* (aula small); cerebral hemispheres extended vertically; Amphibia, Dipnoi, Reptiles, Birds and Mammals.
Monocœlia (encephalocœle single; neuron epaxal only) = cephalochorda = acrania = leptocardia = monolocularia. Branchiostoma.	*Polycœlia* = craniata = pachycardia = multilocularia; neuron partly preaxal.
Cryptocœlia (neurocœle transitory) = Ametamera = Urochorda = Tunicates.	*Phenocœlia* (neurocœle persistent) = Metamera = Branchiostoma + other vertebrates.
Stereoneura (nervous centers solid if present) = most "Invertebrates."	*Cœloneura* (hollow neuron = Chordata (+ Enteropneusta?).
	Metazoa.

EVIDENCE CONFIRMATORY OF MASTODON OBSCURUS LEIDY, AS AN AMERICAN SPECIES. By R. P. WHITFIELD, New York, N. Y.

IN 1852 Dr. J. Warren figured and described a Mastodon tooth supposed to be from Maryland, considering it as a new species but calling it provisionally *M. angustidens*, fearing it might be European. Subsequent evidence, however, showed it to be from Miocene beds near Greensboro, Caroline Co., Md. Later Dr. Leidy described his *M. obscurus* (Ext. Mammalia N. Am., p. 396) from a molar tooth in the collection of the Acad. N. S. Phil., and a cast of that used by Dr. Warren, the "Baltimore tooth."

This species *M. obscurus* has been questioned owing to the uncertainty of the material used, none of them having known localities. In 1884 (Am. Naturalist, p. 526) Professor Cope says it "rests on a lower molar of uncertain origin" and that "its relations have yet to be determined."

Among Mastodon remains in the Am. Mus. Nat. History, I find two sixth molar teeth corresponding to the "Baltimore tooth" of Dr. Warren, and to Dr. Leidy's *M. obscurus*. They are from the collection of Dr. F. S. Holmes and were dredged from the rivers near Charleston, S. C., one of them bearing on its surface evidences of this in the numbers of Balani parasitic upon it.

The larger tooth measures 7¾ inches in length, and is a sixth molar from the right side of the lower jaw. The cusps are but little worn, showing but little use. Its outline is rounded at each end, and somewhat wider behind the middle than in front. It bears four transverse ridges and a posterior spur; the latter uniting with the fourth ridge so as to form an imperfect circle, hollow in the middle. The three anterior ridges are each composed of four prominent nipple-shaped tubercles or cusps, imperfectly separated by vertical channels; while the ridges are separated by deep, rather wide valleys, interrupted along the median line by smaller and lower tubercles jutting out from the principal ridges, and would in wearing down present the clover-leaf or cruciform pattern characteristic of the worn tooth of the *M. longirostris* group. There is present also a strong cingulum, or basal band, which is strongly crenulated on the inner side of the tooth, but nearly obsolete on the outside. The basal margin of the tooth is strongly lobed at the ridges, and the surface of the tubercles beautifully marked with fine longitudinal wrinkled lines, which have extended over much of the surface. The roots or fangs are constricted below the cingulum, and are bent backward obliquely from the plane of the crown. The enamel is thick and much blackened, as are most of the remains dredged from the Ashley and Cooper rivers.

The second tooth is much smaller and much worn.

These teeth, as also those used by Dr. Leidy, and Dr. Warren's "Baltimore tooth" closely resemble those of *M. longirostris*, more than those of *M. augustidens*, to which species Dr. Warren referred it.

From the location from which these specimens must have come it would appear doubtful if they can with safety be referred to any definite geological horizon, as material from beds of different ages, Eocene, Miocene and Postpliocene are found associated in the dredgings. But Dr. Emmons in his report on the North Carolina Geological Survey, 1858, page 199, figures a three-ridged tooth of this species, obtained from beds of Miocene age, and the locality of Dr. Warren's specimen is now known to be Miocene; so we may safely consider it as pertaining to an older geological epoch than *M. giganteus*.

NOTE.—Since reading the above paper the author has examined a large collection of teeth from dredgings near Charleston, S. C., most of which pertain to this species, but presenting features similar to both *M. angustidens* and *M. longirostris*.

THE PINEAL EYE IN EXTINCT VERTEBRATA. By Prof. E. D. COPE, Philadelphia, Pa.

[ABSTRACT.]

THE foramina in the upper surface of the head in Bothriolepis and Mycterops were described.

The same, with the cast of the brain case of the *Diadectes phaseolinus* was described.

The cast of the brain case of *Belodon buceros* was described.

THE MECHANICAL ORIGIN OF THE SECTORIAL TEETH OF THE CARNIVORA. By Prof. E. D. COPE, Philadelphia, Pa.

1. *Origin of the trituberculur molar.*

THAT primitive mammalia had simply conical teeth throughout[1] is indicated by their reptilian origin. The number of teeth in some of the Jurassic genera, premolars four, molars eight, is in excess of that typical of Mammalia, approaching in this respect, also, the Reptilia. Teeth with simple crowns alternate in each jaw with those of the opposite one. The first step in complication has been the addition of a basal cusp at each face, one anterior, the other posterior.[2] This stage is seen in the genus Triconodon, Owen. These cusplets fill up the spaces between the teeth, and thus produce a certain amount of interference between those of opposite jaws. As the lower jaw closes within the upper, a wedging movement between parts of the teeth which oppose each other takes place. It results that the cusplets, being opposite to each other, experience a greater lateral pressure than the large central cusps. The effect of the collision between the cusplets would be to emphasize the relation still more; that is, the cusplets of the upper jaw would be wedged outward, while those of the lower jaw would be pressed inward, the major cusps retaining at first their original position. But with increase of the size of the teeth with all the cusps, the major cusps would soon assume in each jaw a position more or less transverse to that of the cusplet in both jaws, producing, as a result of the crowding, crowns with triangular section.

2. *Modifications of the tritubercular molar.*

The first modification of the tritubercular lower molar of the lower jaw is the addition of a low cingulum at the posterior base. This is seen in a rudimentary condition in various living species of the Centetidæ and Chrysochlorididæ of the Insectivorous order; but in these existing forms the superior molar has added a posterior cingulum also, which

[1] On the Homologies of the Molar Teeth in the Mammalia Educabilia, Journal Academy, Philadelphia, 1874.

[2] American Naturalist, 1885, p. 350.

widens internally or towards the palate. In the evolution of the dentition, the inferior posterior cingulum or "heel" was developed first as in the genera Deltatherium, Didelphodus and Stypolophus, where it is quite large, while the superior cingulum is wanting in Stypolophus and Didelphodus, but is present in a very rudimentary condition in *Deltatherium fundaminis*. In all of these genera the external cusps of the superior series have been pressed inwards, and more or less together, and are, therefore, removed in this respect from the primitive condition. The more primitive state of the superior cusps is seen in some species of Mioclænus where, however, the posterior cingulum is developed. The primitive type of tritubercular superior molar is that of Sarcothraustes, and in the same genus the inferior molar only differs from the primitive type in having a well-developed heel. Among recent mammals the carnivorous and insectivorous marsupials generally have the tritubercular lower molar with heels. In the Chiroptera and many Insectivora the heel is largely developed and supports two cusps, as it does in some Creodonta.

From this point the evolution of the tritubercular molar must be considered from two standpoints. The first is the mechanical cause of the changes in its form, and the second is the mechanical cause of its definite location in a particular part of the jaw. For it is now well known that in the evolution of the sectorial dentition of the Carnivora, the number of molars and premolars has considerably diminished.

In the tritubercular dentition the crowns proper of one jaw alternate with those of the other, while the heels in either jaw will oppose such part of the crown of the teeth in the opposite jaw as come in contact with them when in use. The development of the heel in the inferior molars produced a type which is known as the tuberculo-sectorial. This type characterizes the Creodonta or Eocene flesh-eaters. Three such teeth existed in most members of that sub-order.

The successive modifications of form which have resulted in the existing specialized single sectorial tooth of the Felidæ have been already pointed out.[3] They were shown to consist in the gradual obliteration of the internal and posterior tubercles and the enlargement of the external and anterior tubercles of the primitive triangle, together with the extinction of the heel. The modification in the character of the dentition, taken as a whole, was shown to consist in the reduction in the number of the teeth, including the sectorials, until in Felis, etc., we have almost the entire function of the molar series confined to a single large sectorial in each jaw.

The genesis of the sectorial tooth is explained, as follows: In consequence of the fact that the lower canine tooth shuts anterior to the superior canine, the result of the enlargement of the diameters of those teeth will be to cause the crowns of the inferior teeth to be drawn from behind forwards against those of the superior teeth at the moment of closing the jaw. Thus, a shearing motion has resulted between the anterior external

[3] American Naturalist, March, 1879.

edge of the lower triangle and the posterior internal edge of the superior triangle. Now, the true sectorial teeth consist in the enormous extension of these same edges, in a fore and aft direction, the inferior shutting inside of the superior. To account for the development of these blades, we must understand that the oblique pressure of the front edge of the lower molar tooth on the hind edge of the superior molar tooth has been continued for a very long time. We must then observe that the internal tubercle of the superior triangle has been pushed continually forwards and been reduced to a very small size. Why should this occur? Why should not the corresponding tubercles of the inner side of the lower crown have been pushed backward, since action and reaction are equal. The reason is clear: the superior tubercle is supported by but one root, while the resistant portion of the inferior crown is supported by two, thus offering twice the resistance to the pressure that the superior does. But why should the anterior part of the inferior tooth move forward, even if it be in the direction of least resistance? This is due to the regular increase in size of the teeth themselves, an increase which can be traced from the beginning to the end of the genealogical series, and this increase is the usual result of use.

The excess of the forward pressure of the inferior teeth against the superior, over any backward pressure, has left the posterior internal cusp of the triangle of the inferior molar without contact or consequent functional use. It has consequently gradually disappeared, having become small in the highest Canidæ, wanting in some Mustelidæ and all Felidæ. The heel of the same tooth has had a similar history. With the diminution in size of the first superior tubercular, with which it comes in opposition in mastication, its functional stimulus also diminished and disappeared, sometimes a little sooner (Felidæ), and sometimes a little later (Hyænidæ) than that tooth.

8. *Location of the sectorial tooth.*

The specialization of one tooth to the exclusion of others as a sectorial, appears to be due to the following causes: It is to be observed in the first place that when a carnivore devours a carcass, it cuts off masses with its sectorials, using them as shears. In so doing it brings the part to be divided to the angle or canthus of the soft walls of the mouth which is at the front of the masseter muscle. At this point, the greatest amount of force is gained, since the weight is thus brought immediately to the power, which would not be the case were the sectorial situated much in front of the masseter. On the other hand, the sectorial could not be situated farther back, since it would then be inaccessible to a carcass or a mass too large to be taken into the mouth.

The position of the sectorial tooth being thus shown to be dependent on the masseter muscle, it remains to ascertain a probable cause for the relation of the latter to the dental series in modern Carnivora. Why, for instance, were not the last molars modified into sectorial teeth in these animals, as in the extinct *Hyænodon* and various Creodonta? The answer

obviously is to be found in the development of the prehensile character of the canine teeth. It is probable that the gape of the mouth in the Hyænodons was very wide, since the masseter was situated relatively far posteriorly. In such an animal the anterior parts of the jaws with the canines had little prehensile power. They, doubtless, snapped rather than lacerated their enemies. The same habit is seen in the existing dogs,[4] whose long jaws do not permit the lacerating power of the canines of the *Felidæ*, though more effective in this respect than those of the *Hyænodons*. The usefulness of a lever of the third kind depends on the approximation of the power to the weight; that is, in the present case, the more anterior the position of the masseter muscle, the more effective the canine teeth. Hence, it appears that the relation of this muscle to the inferior dental series depended originally on the use of the canines as prehensile and lacerating organs, and that its insertion has advanced from behind forwards in the history of carnivorous types. Thus, it is that the only accessible molars, the fourth above and the fifth below, have become specialized as sectorials, while the fifth, sixth and seventh have, first, remained tubercular as in the dogs, or, secondly, have been lost, as in hyenas and cats.

The reduction in the number of the molars directly as the increase in the size of the canines commenced as early as the Jurassic periods in certain types,[5] as in Triconodon, Owen, and Paurodon, Marsh, where the canines are large and the molars few.

The reduction of the molars directly as the increase in size of the incisors is also seen in the Rodentia and Proboscidia. The mechanical reasons for this differ from those effective in the case of flesh-eating Mammalia, and will be treated at another time and place.

REMARKS ON THE DEVELOPMENT OF PETROMYZON. By Prof. W. B. SCOTT, Princeton, N. J.

[ABSTRACT.]

MY paper in the Morphologisches Jahrbuch for 1881 gives an account of the development of Petromyzon down to the time of hatching, but many important steps take place during the larval condition. In the central nervous system all the parts are already present and the only changes which occur are in the form and proportions of these parts, the most remarkable being the correction of the cranial flexure, which is almost complete and real, not apparent as in the higher vertebrates; the upper lip and neighboring structures rotating through 180°, which has a profound effect upon the development of the head. The nasal epithelium arises from a thickening of the epiblast median in position and originally on the ventral side of the head; the rotation and growth of the upper lip bring it

[4] Excepting in the bull-dog, whose muzzle is as short as that of the Felidæ.
[5] My friend, Prof. H. F. Osborn, has directed my attention to this fact.

to the dorsal side of the head and give it a deeper seat. The folds appear very late in larval life just before metamorphosis. A diverticulum from the base of the nasal sac becomes by successive stages a glandular structure which may be homologous with Jacobson's Organ. The hypophysis is derived from a prolongation of the nasal sac originally separate from it. Dohrn's interpretation of this is manifestly erroneous. The eye is peculiar in that only a small part of the outgrowth from the brain becomes the retina, due to the fact that during larval life the eye is functionless. The cranial and spinal nerves are outgrowths from the central axis. Though in some of the former the ganglia are derived partially from the epiblast. The branchial sense organs are found independently and much later than the ganglia. The cranial nerves back of the ear and all the spinal nerves are at first connected by a continuous commissure. The IX and X nerves are at first composed of many separate nerves and ganglia but early coalesce into a very complex mass.

ORIGIN OF AMERICAN CARNIVORA. By Prof. W. B. SCOTT, Princeton, N. J.

[ABSTRACT.]

IN the lower Eocene of the United States no true Carnivora occur, and probably not in the middle or Bridger Eocene. Here, however, we find the *Miacidæ* a family of Creodonts, differing from all other families of that order in the possession of sectorial teeth homologous with those of the Carnivora. The Uinta formation probably possesses *Amphicyon*, which I regard as the starting point of all the fissipede forms. This animal had a complete dentition, was plantigrade, pentadactyl, the femur had a third trochanter and the humerus an epicondylar foramen. The foramina of the skull are rather arctoid in character. From *Amphicyon* we pass in one direction to *Cynodictis* of the White River Miocene thence to *Aelurodon* and *Canis* of the Loup Fork. The arctoid or bear series is from *Amphicyon* to *Hyænarctos*, with side branches to the *Mustelidæ* *Procyonidæ*, etc. The arctoid series would seem to be entirely of Old World origin and to be comparatively late immigrants to America. The earliest cats like the *Proælurus* of France and *Dinictis* of America show their close relationship in all points to *Amphicyon* in being plantigrade, pentadactyl, femur with a third trochanter, claws simple, teeth numerous, sectorials with large heels, etc. These animals are closely like the *Cryptoprocta* of Madagascar and gave origin to three distinct lines, the *Viverridæ* of the Old World, the true cats, and the false sabretooths or *Nimravidæ*. The changes in dentition can all be traced step by step. No arctoid animal is known from America before the Loup Fork, which has furnished *Putorius*. This brings us to the conclusion that the Cynoidea or dogs are the nearest modern representatives of the ANCESTRAL type of all land Carnivora.

PRELIMINARY PAPER ON STRUCTURE OF ALOSA SAPIDISSIMA. By FANNY R. HITCHCOCK, New York, N. Y.

[ABSTRACT.]

IN the connective tissue between the myatoms in the muscle of the lateral line of *Alosa sapidissima*, there are developed a series of thin cartilaginous plates irregularly triangular in outline, the apex of the triangle forming the proximal part and the irregularly lobed base the distal portion of each plate. The cartilages lie in a vertical plane and incline outward and backward.

The apex of the cartilage is anterior to and slightly overlaps the distal extremity of the epicentral belonging to the segment in which the cartilage is developed.

The epipleurals in Alosa are not united to the ribs, but the proximal extremity terminates at some distance from them. They follow the dorsal line of the intermuscular septa of the ventro-lateral mass of the lateral muscle and pass below the ventral edge of the cartilage plates of the muscles of the lateral line, being separated from them by a small space. In the anterior body segments, directly beneath the pectoral arch, the cartilage plates are wanting and the segments themselves have, to some extent, coalesced. Posteriorly, the plates are developed throughout the abdominal segments. In the segments in which the cartilage plates are wanting, the epipleurals are also undeveloped, unless represented by the scapula, which in the adult is represented by a very small bar of cartilage, or is wanting entirely. The anterior two epipleurals are short, have coalesced and are attached by their proximal extremity to the post-clavicle.

The spines of the corresponding abdominal vertebræ are inclined toward each other.

A consideration of these cartilages and their relation to the other segmental skeletogenous elements leads to the opinion that they represent early stages in the development of new organs, rather than a reversion to a former condition. They afford strong confirmatory evidence of the theory that the sense organs of the head are highly specialized integumentary sense organs, corresponding to the organs of the lateral line and show how the cartilaginous capsules of these head organs might have originated.

The following suggestions are also offered for consideration:

1. That the mandibular, hyomandibular and hyoid arches, the extra branchials of Parker, the scapular portion of the pectoral arch and the epipleurals are homologous structures.

2. That the coracoid portion of the pectoral arch and the supporting bones of the pelvic fins may be homologous with the spines of the abdominal vertebræ.

3. That the distal or free portion of the paired limbs may be derived from cartilage plates, similar to those described above, but developed in connection with a specialized line of integumentary sense organs situated more ventrally than those of the lateral line we have been considering.

The arrangement of the lateral sense organs in amphibian larvæ show such a line developed ventrally and connecting the fore and hind limbs. If such a development took place, an explanation of the cephalic fin of certain Elasmobranchs, as a survival or a reversion, would be possible.

ON THE HOMOLOGIES OF EDESTUS. By FANNY R. HITCHCOCK, New York, N. Y.

[ABSTRACT.]

THREE theories have been proposed as to the homologies of the curious fossils which form the genus Edestus of Leidy, viz.:

1. Doctor Leidy's view, now no longer held, that they were remains of the segmented maxillary bones of some extinct plagiostomous fish.

2. Sir Richard Owen's theory that they were fish spines. This view was also proposed by Doctor Newberry and has been generally accepted until lately.

3. The view recently proposed by Dr. H. Woodward of London, in his account of a remarkable fossil from Australia, referred by him to this genus. Doctor Woodward suggests that these fossils are pectoral fins similar in character to those of Pelecopterus (Cope).

The object of this paper is to examine the evidence for and against these views and to present for consideration a fourth view, viz.: that the fossils in question are teeth with the bases enormously developed; they arose probably in the median line between the mandibles, and were attached to a membranous or cartilaginous support in the American form, or to an osseous median piece in the Australian.

This support being developed in the median line between the rami of the lower jaws would sustain the same relation to the mandibular arch that the glosso-hyal does to the hyoid.

To support such a theory, we have: 1. The segmented character of the fossils, the segments being evidently freely movable on one another; such a structure would be very anomalous in a spine or a fin, such as that of Pelecopterus. The mode of growth of the segments seems to have been in a regular series from before backward, while in Pelecopterus the new fin rays are intercalated between the older ones. The finding of single segments of different sizes would indicate that they were shed like teeth.

2. The structure of the denticles is similar to that of the teeth of the Petalidæ with which they are frequently, if not always, associated as I am informed.

3. The presence of an osseous support in the Australian form, which support though more slender, and longer, is very similar to that in Onychodus.

4. The overlapping of the segments, which is very great in the American forms, is very slight in the Australian, but it is characteristic of the bases of the median teeth in *Onychodus sigmoides* from the Devonian of Ohio.

5. The bilateral symmetry, the ligamentous attachment, which extended to the base of the denticles, and the absence of any trace of articulation render it doubtful if there can be any homology between the Edestus remains and the pectoral fins of Pelecopterus, while the theory of a dorsal spine seems untenable in the presence of a basal bone, such as is shown in *E. Davisii* (Woodward, sp.).

ON THE PHYSIOLOGY OF THE HEART OF THE SNAKE. By Prof. T. WESLEY MILLS, Montreal, Canada.

[ABSTRACT.]

1. THE investigations recorded in this paper were made in mid-winter on fasting but not hibernating animals.

2. Comparison of the vagi showed that in every instance both nerves were efficient, but usually the right was the more so; in some cases the difference, if actual, was minimal.

3. Stimulation of the vagi leads to after increased force and frequency of beat, or of the former only, and according to the law[1] of inverse proportion previously announced by the writer.

4. The mode of arrest of the heart is identical with that noted in the chelonians, fish, etc.; the same applies to the mode of recommencement.

5. During vagus arrest the *sinus and auricles* are inexcitable.

6. There are certain peculiar cardiac effects not explicable by reference to the vagi nerves alone, but which put the sympathetic system of nerves in a new light.

7. Direct stimulation of the heart confirms results previously noted by the writer for other cold-blooded animals. Arrest is in all the animals of this class yet examined owing to stimulation of the terminals of the vagi within the heart's substance.

8. As regards independent ventricular rhythm, the results have been negative.

9. The heart of the snake upon the whole seems to lie physiologically between that of the frog and of the chelonians.

OBSERVATIONS UPON THE FŒTAL MEMBRANES OF THE OPOSSUM. By Dr. HENRY FAIRFIELD OSBORN, Princeton, N. J.

[ABSTRACT.]

THIS paper described the discovery of a female opossum with the young *in utero* shortly before birth.

There were nine young in each horn of the uterus. The membranes consisted of a large, vascular *yolk-sack* united with the subzonal membrane and forming a disc-like area covered with amœboid subzonal cells. This area was *closely attached* to the polygonal cells covering the utricular glands of the uterine epithelium. The *allantois* was also attached to the subzonal membrane, forming a richly vascular area which was covered with flattened cells but not in any case attached to the wall of the uterus.

[1] Journal of Physiology, Vol. VI, p. 281, *et seq.*

The function of the *yolk-sack placenta* is inferred to be the transmission of the secretions of the utricular glands to the embryo, by means of the umbilical vessels. The function of the allantois is either respiratory or the absorption of the fluid secreted in the uterine cavity by the utricular glands.

THE RELATION OF THE COMMISSURES OF THE BRAIN TO THE FORMATION OF THE ENCEPHALIC VESICLES. By Dr. HENRY FAIRFIELD OSBORN, Princeton, N. J.

[ABSTRACT.]

THIS paper suggested an hypothesis for the well known and constant phenomenon of the division of the embryonic brain into four swellings or vesicles. This consists in the constant presence of three dorsal commissures or, more strictly speaking, *decussating tracts* between the vesicles. These decussating tracts appear simultaneously at an extremely early period in embryonic life. The first was discovered by the writer as the primitive or degenerate condition of the cerebellum in the Urodele Amphibia. The second is found in the posterior commissure, which, according to Pawlowsky's observations as confirmed by the writer, consists also of nerve tracts decussating dorsally. The third is found in the superior commissure, which has been independently observed by Bellonci and the writer, also consisting of decussating tracts. These three commissures are primitive features of the brain and they appear in each case between the vesicles, *i. e.*, in the constrictions of the roof and sides of the primitive neural tube forming the primary fore brain, the secondary fore brain, the mid brain and the hind brain. It is suggested that there may be a serial homology between these commissures, and that they may bear a causal relationship to the vesicles.

ON THE PHENGODINI AND THEIR LUMINOUS LARVIFORM FEMALES. By Prof. C. V. RILEY, U. S. Entomologist, Washington, D. C.

[ABSTRACT.]

THE paper gave a brief history of the discovery and the characteristics of the ♀ in Phengodes and Zarhipis and showed the difficulty of distinguishing between it and the larva proper. Described the egg, newly hatched larva and pseudo-pupa. Mentioned other luminous larvæ in Coleoptera and discussed the bearing of luminosity on arrested development.

THE BUFFALO-GNAT PROBLEM IN THE LOWER MISSISSIPPI VALLEY. By Prof. C. V. RILEY, U. S. Entomologist, Washington, D. C.

[ABSTRACT.]

THE paper gave the results of late investigations into the habits of the species of Simulium so injurious to stock in the Southern States. The life history was traced of the two more important species, *Simulium pecuarum*, n. sp. and *Simulium meridionale*, n. sp.

THE PROBOSCIS OF THE MOSQUITO. By Prof. G. MACLOSKIE, Princeton, New Jersey.

[ABSTRACT.[1]]

ANATOMY of mouth-parts and special description of the labial sheath; comparison with proboscis of Musca and homology of parts. The ducts of the thoracic salivary glands and of a median, or poison-gland, unite into a single duct with spiral thickenings. This duct bifurcates in the neck, its branches proceeding to the two mandibles which are perforated as fangs for discharging the fluid into the wound.

ON THE EARLY HISTORY OF THE FOOT IN PROSOBRANCH GASTEROPODS. By HENRY LESLIE OSBORN, Ph.D., Hamline Univ., Hamline, Minn.

[ABSTRACT.]

THE literature of animal morphology is becoming more and more devoted to the subject of organogeny. The study of the development of organs is throwing much light on the story of their origin, the origin of species as well. The testimony of authors on gasteropod morphology prior to 1886 is to the effect that the foot throughout the group arises as a median elevation of the ectoderm upon the ventral surface behind the blastopore. Among the various writers, who have given expression to this view are Carpenter, Bobretzky, Koren, Butschli, Salensky, Rabl, Balfour and others, and their researches have extended to *Fusus*, *Nassa*, *Natica*, *Cytheræa*, *Trochus*, *Vermetus*, and *Paludina*. Their reports leave little doubt of their observations on this point.

MacMurrick, in a paper in 1886, on the development of Prosobranchs, figures but does not describe the first appearance of the foot in *Fulgur* not as a median but as a paired structure.

In studies in 1884 upon Fasciolaria and Fulgur I observed and figured the first stages in the development of the foot. In both cases it arises as a pair of entirely independent elevations in the ectoderm behind the velum and blastopore on the ventral surface. Sections show them filled with mesoderm the beginnings of the musculature, and the nervous system of the foot arises as two independent parts later united. It is very early that the two separate mounds coalesce to form the single median structure which persists as the peculiar form of foot.

In view of these observations it would appear that we must accept an amendment to the current statement of the facts as to the origin of the Prosobranch foot to the effect that in some cases (so far as at present known two cases) the organ is at first a paired structure like the beginnings of locomotor appendages in arthropods and vertebrates and only later in the ontogeny median in position.

Further we may open the question whether these facts may be taken to have phylogenetic significance or to be a falsification of the phylogenetic record. The latter view would seem improbable because the foot in gasteropods is of no use in the early larval life, the velum being the organ of locomotion.

It would be equally difficult to see how the paired condition of the foot could have been acquired secondarily from an ancestral form with a single median one, both because of its probable rarity in the group and because of the absence of function of the foot in early life. On the other hand the supposition that the gasteropod foot originated as a median structure from the ventral creeping surface of a Vermian ancestor would seem natural and easy being in accord with the facts of anatomy and the few hitherto published facts of embryology. In thus seeking a meaning for this appearance in these two forms, which deviates from the position commonly held, I have no desire to attempt to force a few facts to support a superstructure of speculation but rather to propose the question for future determination when a larger number of forms shall have been studied.

ON THE ORIGIN, DEVELOPMENT, AND PREVALENCY OF THE SO-CALLED ECHINOCOCCUS. By DR. CHAS. PORTER HART, Wyoming, O.

[ABSTRACT.]

THE object of the author in presenting this paper was stated to be, not so much to study the morphology of the so-called Echinococcus, as it was to show how rapid is becoming the spread of this dangerous parasite in some parts of our country — a parasite which, in its sexually immature condition, is probably more fatally injurious to man than all the other species of entozoa combined. A brief review, however, of the various morphological changes which it undergoes in man and in the lower animals, was first given, partly in order that a correct diagnosis might be more readily made in these cases, but chiefly with a view to exhibit the strict relation which its presence in man bears to the degree of intimacy subsisting between him and the domestic dog — a fact now well established, and of the highest importance in a sanitary point of view.

After describing and exhibiting various specimens recently obtained, the author stated, that within a period of about thirty years he had met with no less than seventeen well-recognized cases; that many more doubtless escaped detection from the obscurity of the attending symptoms, or from want of care in observation. But one of these cases occurred more than twenty years ago, while more than two-thirds of them were noticed within the last decade, and no less than three within the last twelve months. From this he inferred that the disease is rapidly on the increase,

and that it behooves men of science to enlighten the general public on the subject to the fullest possible extent. This the author attempted to do, as far as the occasion offered, by describing the various circumstances under which the germs are known to be distributed, through the air, water, and other media.

LOCOMOTION AND BILATERAL SYMMETRY. By Dr. JOSEPH JASTROW, Philadelphia, Pa.

[ABSTRACT.]

THE problems of bilateral symmetry—culminating in the problem of left and right-handedness in man—are in part dependent for their solution on a correct understanding of the nature of animal symmetry. The only suggestion regarding this insufficiently treated question that (to my knowledge), is at all satisfactory is that offered by Eduard Weber (Berichte of the Leipzig Academy, 1849). According to this view bilateral symmetry is associated with and due to progressive locomotion. This generalization is supported by the following considerations: 1. Animals are symmetrical with reference to the plane of motion, and the motor-organs as well as the sense-organs that guide motion are again symmetrically disposed with regard to the same plane. 2. Such animals as require the most delicate equilibrium in their mode of progression have the most perfect symmetry; flying animals have a finer symmetry than walking animals, and the latter a finer than swimming animals. An interesting application of this view to the question of right-handedness is given by Weber. He weighed the dissected muscles of each half of the body and found the ratio of the weight of those of the right arm to those of the left to be as 1 to .929, in the legs as 1 to .936, in the trunk as 1 to .992. In other words the trunk, where asymmetry would most interfere with locomotion, is most symmetrical, and those parts where specialization is greatest, most asymmetrical. In general then, the specialization of function exemplified in right-handedness is possible only when not interfering with locomotion and its extent is limited by such interference. A second test is suggested by the generally accepted conclusion that primitive man—to whom speedy locomotion was more necessary than to us—was more ambidextrous and thus more symmetrical.

An experimental verification of this view is possible by asymmetrically mutilating and weighting animals and ascertaining whether such mutilation or encumbrance interferes more with locomotion than a symmetrical lesion or encumbrance. Experiments were made upon the common house fly that make this verification decidedly probable. These observations are offered as a preliminary suggestion and in the hope of inciting others to more extended observations directed to the same object.

A POINT IN DERMAL PHYSIOLOGY WITH DEMONSTRATION OF A NEW AESTHESIOMETER. By Dr. JOSEPH JASTROW, Philadelphia, Pa.

[ABSTRACT.]

FURTHER advance in our knowledge of the sensations accompanying contact of the skin is dependent upon an improvement in the methods of observation. For this object I have devised the instrument which I term my aesthesiometer.

The points of improvement to which attention is expressly called are the following:

(1) The points are no longer held in the hand, but are firmly mounted. We thus are sure that the two will touch at once and with equal intensity; the contact is the same one time as the next, and the time of contact can be regulated.

(2) The distance between the points is easily set and accurately measured.

(3) The points can be applied at any angle.

(4) The points can be used separately as in "successive" experiments, and any number of points can be used.

(5) The points can be applied to any part of the body; vertically, horizontally or obliquely as convenience directs.

(6) By using a double apparatus two pairs of points can be applied to the same points of the skin, or simultaneously on symmetrical portions.

(7) Points of any kind can be inserted; type, rods, and forms of any kind can be used.

(8) The points can be moved continuously along the skin.

(9) The instrument can be used for locating and mapping out "hot" and "cold-points."

(10) By making electrical connections the reaction-time for touch can be measured.

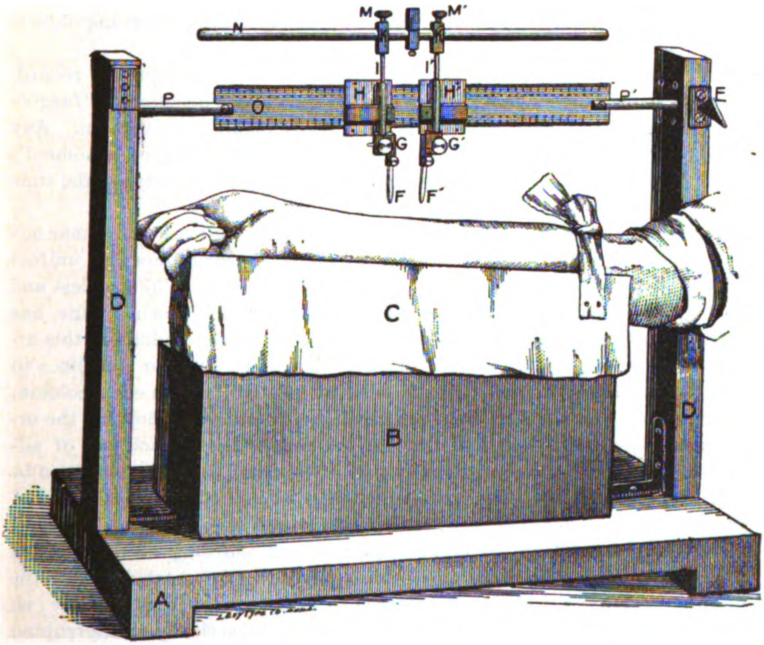
To test the instrument I experimented upon the distance-sense of the skin. The part used was the volar surface of the lower arm. Three points $\dot{a}\ \dot{b}\quad \dot{c}$ (a, b and c) were chosen so that the mean between ac and bc was constant at 48 mm; ab was 6 mm. in one series, 12 mm. in another. An observation consisted in applying the points to a and c and then to b and c; or, *vice versa*, the subject to tell whether the larger or smaller distance was first applied. The errors in 100 observations in each of three subjects were:

A. Wnen $a\,b$ = 6 mm.	I	30	II	30	III	29.
B. When $a\,b$ = 12 "	I	9	II	12	III	14.

To test whether this amount of error is due to the sensibility of the skin at $a\,b$, that sensibility must be measured. The old way (which I believe to be ambiguous as well as crude) would be to find at what distance two compass-points seem double as often as single. This is, for I, 12 mm.; for II, 15 mm., for III, 14 mm. If this were the standard the above errors are far too few. A better method is to apply now a single point, now a

double and find the proportion of error in telling which is which. In this way, with *A*, I had 20; II, 18, and III, 30 errors in 100. With B I, 18; II, 12; III 18; which again is a greater amount of error than before in *B*, though less in *A*. But the fairest test is simply to omit *c* and alternately use *a* and *b* in pairs; the subject to detect the order of each pair. The errors are $\left\{\begin{matrix} A. & \mathrm{I}\ 20 & \mathrm{II}\ 16 & \mathrm{III}\ 22 \\ B. & \mathrm{I}\ 8 & \mathrm{II}\ 5 & \mathrm{III}\ 7 \end{matrix}\right\}$ a smaller amount of error, thus indicating that the stimulation of *c* interferes with the maximum discriminability. The theoretical bearing of these facts must be postponed until more observations have been made.

The author desires to gratefully acknowledge that this apparatus was constructed by aid of a grant from the Elizabeth Thompson Science Fund.



The essential parts of the instrument are as follows: A base, *A*, to which is attached a pair of uprights, *DD'*; a block, *B*, upon which rests a frame, *C*, for receiving the arm which is held in position by grasping the band as shown in the cut. A fine millimeter scale, *O*, with two arms, *PP'*, through which it is fastened at *E*, at any desired angle; upon this scale are two carriages, *HH'*, sliding along it with as much or as little friction as is desired. At *G* there is a small "knee" that can be firmly screwed and holds the points, etc., *FF'* (any number and size of these knees can be made). Above are two rods, *II'*, connected with two head pieces, *KK'*, through which passes a steel rod, *N*. The carriage is held in a fixed position by screwing down the screws at *MM* and the two points are made to touch the skin by pressing the button at *L*, which presses down a spring that, in turn, releases the points. The stand and accessory appliances are of wood, the rest of brass and steel. The length of the scale, *O*, is thirty decimeters.

ON CATALOGUING MICROSCOPICAL PREPARATIONS. By R. H. WARD, M.D., Troy, N. Y.

[ABSTRACT.]

THIS proposed system of recording microscopical preparations is the outgrowth of the writer's experience in trying to make a collection of slides as useful as possible, as objects of reference in teaching as well as in study, and with the least possible expenditure of time or trouble. It is primarily intended for those students who need not, and will not, undertake to maintain the more cumbersome system of a card catalogue; but even for the specialist, with the facilities of a laboratory at command, it continues to be available in connection with the card catalogue, as a serial list and for the temporary preservation of memoranda concerning objects in course of preparation.

Much labor is wasted by accumulating slides without proper record, many valuable objects being laid aside and their exact peculiarities forgotten before their owner realizes that he is really making a collection. Any slide worth preserving, for any scientific purpose, is worthy of a moment's delay in making an accurate, thorough and systematic registry at the time of acquiring it.

The really valuable data concerning a prepared slide are too numerous to be selected and arranged by memory alone, thoroughness and uniformity of description requiring some artificial assistance. The simplest and best arrangement would be that of separate columns down a page, one column for each item; but the items are too numerous to admit of this arrangement on a page of convenient size. By giving three or four lines to each entry, however, and a like number of related items in each column, the end can be attained without practical disadvantage. Adopting the ordinary 4to size of a page, and carrying the entries across each pair of adjacent pages, an area equivalent to that of a postal card can be given to each object, with ten entries, conspicuously separated by horizontal red lines, to each opening of the forms when bound in a book; an arrangement most convenient for rapid reference, and affording adequate space for general use. The items most commonly desired are tabulated at the head of each page, and merely referred to by suggestive letters below; so that the description of each slide appears as a practically uninterrupted block of MS. and substitutions of other data can be readily made according to individual necessities. Pages for 3000 objects, if required, with blank sheets for long notes, and an alphabetical index sufficient for five or six cross references to each object, can be bound in a volume of not inconvenient size. The index is ruled for convenience in entering titles and numbers, and is lettered alphabetically, with subdivision on the vowel system, the assignment of pages depending on the frequency with which the various letters occur at the beginning of English words. The following table shows an itemized form of very general availability for the serial pages:

SLIDE NO.	NAME.	SOURCE.
	c. Common Name. s. Scientific Name. N. Special points shown, Illumination or Powers required, Reference to authorities, etc.	h. Habitat or Locality. c. Collector (Presented, Purchased, Exchanged, etc.)
50 *	c s N	h c

	PREPARATION.	MOUNTING.
	p. Preserved (Hardened, Macerated, Decalcified, Injected, etc.) ct. Cut (Embedded, Frozen, Microtome), Teased, etc. st. Stained. cl. Cleared.	m. Mounting Medium. cc. Cell and Cement. cg. Cover-glass Thickness. d. Date. lc. Location in Cabinet. r. Repairs or Disposal (Broken: Cement run in: Air in: Given to or Exchanged with: etc.),
50 *	p ct st cl	m cc cg d . . lc. r

* Repeated nine times down the page, for Nos. 51–59.

DEVELOPMENT OF THE UMBELLIFER FRUIT. By JOHN M. COULTER and J. N. ROSE, Crawfordsville, Ind.

[ABSTRACT.]

IN no family of plants does the fruit furnish more certain diagnostic characters than in the Umbelliferæ. This indicates an unusual amount of differentiation in the fruit structures and a great diversity in its display. For some time past we have been making a critical examination of all our Umbelliferæ east of the 100th meridian, and this has directed special attention to the minute structure of the fruit of all our species. It was a matter of considerable importance to study the development of these structures, for which purpose our common *Chærophyllum procumbens* was selected as a type. Beginning with ovary wall composed of undifferentiated parenchyma, supported by simple fibro-vascular elements, the changes wrought in the maturing ovary and then in the ripening fruit were traced. The general structure of the pericarp wall well represents the typical leaf structure, with epidermal layers bounding a more or less developed mesophyll. It is in the latter that the characteristic fruit structures are developed. The constant occurrence in the outer epidermal region of two distinct layers of epidermal cells suggests the presence of a connate calyx. The mesophyll region of the pericarp is naturally separated into three structures: (1) oil-ducts, (2) strengthening cells, (3) undifferentiated parenchyma.

I. *Development of oil-ducts.*—In very young buds, groups of three or four parenchyma cells of the pericarp begin to be set apart for the formation of oil-ducts. The first indication of this is the fact that they become secreting cells, and are discolored by the characteristic oily contents. The three or four secreting cells begin to divide radially so that at the time of anthesis the resulting intercellular space becomes an oil-duct of small caliber, with six to eight secreting cells. The radial division continues as the fruit matures, thus gradually enlarging the caliber of the duct. The ducts are thus simply enlarged intercellular spaces, developed by the radial division of the surrounding secreting cells. Hydrocotyle has no oil-ducts, because its secreting cells lack the power of radial division; Conium has none because its secreting cells are in a plane instead of in groups; while most Umbellifers have oil-ducts because the secreting cells are in groups and also have the power of radial division.

II. *Development of strengthening cells.*—In young buds there is no setting apart of this region from the ordinary parenchyma of the pericarp wall. Upon approaching anthesis, however, the parenchyma cells surrounding each fibro-vascular bundle subdivide, and at anthesis quite a distinct group of small parenchyma cells is discovered beneath each rib. This comparatively small size is due not only to cell-division and moderate growth, but also to the strong growth of the surrounding undifferentiated parenchyma. While the region is indicated before anthesis, it does not become really a region of strengthening cells until the development of the fruit. It is then that the walls begin to thicken, until at maturity a group

of strengthening cells is composed of firm heavy-walled tissue. The contained fibro-vascular elements are encroached upon, and for the most part obliterated, as they are really functionless after anthesis. The differentiation proceeds centrifugally from the fibro-vascular elements as a center, at first a comparatively small area being included. The surrounding parenchyma is gradually invaded, until in some cases the whole thickness of the pericarp wall is concerned.

III. *Development of undifferentiated parenchyma.*—This region, lying between the strengthening cell groups, is chiefly concerned in the extension of the pericarp wall. This extension is effected by the radial division of the undifferentiated parenchyma, the amount of tangential cell-division being comparatively small. The exception to this is found in ribs and wings, which represent regions of strong tangential cell-division.

Æcidium on Juniperus Virginana. By Prof. W. G. Farlow, Harvard Univ., Cambridge, Mass.

[ABSTRACT.]

Several species of Gymnosporangium grow on *Juniperus Virginiana* but their Roestelisæ or æcidial forms are found on different Pomeæ. So far no æcidial form has yet been described on *J. Virginiana*. When in Bermuda, in 1882, I found distortions of the branches of *J. Bermudiana* which had a close resemblance to the knots caused by *G. globosum* on *J. Virginiana*. The specimens were collected in January and were immature, but scattered over the knots were the peridia of an æcidium which had not yet opened. The following year, Mr. Walter Faxon visited Bermuda in the summer and, at my request, collected some more of the knots on which the peridia were in better condition than in my own specimens but rather old.

Last January, Mr. F. S. Earle collected on *J. Virginanus* similar knots at Ocean Springs, Miss. An examination shows that the Mississippi specimens are of the same species as the Bermuda plant which is described as a new species, *Æcidium Bermudianum*. It cannot be told with what teleutosporic form this æcidium is collected but it differs from the æcidia of any of the Gymnosporangia known on *J. Virginiana*.

Apical growth in Fucus. By Prof. W. G. Farlow, Harvard Univ., Cambridge, Mass.

[ABSTRACT.]

According to Rostafinski the terminal growth of Fucus is by means of a series of cells of equal value. Recent observations by Mr. W. M. Woodworth show, however, that there is not a series of cells but a single terminal cell in *Fucus furcatus*, *F. filiformis*, and *F. vesiculosus*. This brings Fucus into accord with the other genera of Fucaceæ as far as the growth by a single terminal cell is concerned.

NOTES ON THE FLORA OF THE KITTATINNY MOUNTAINS. By Dr. N. L. BRITTON, Columbia College, New York, N. Y.

THE paper described the remarkable resemblance of the Flora of the Kittatinny Mountains to that of the pine barrens and other sandy coast regions.

ON THE HISTOLOGY OF THE VEGETATIVE ORGANS OF BRASENIA PELTATA PURSH. By Prof. JOS. SCHRENK, Hoboken, N. J.

[ABSTRACT.]

SHORT, introductory remarks referring to the discovery, by the author, of the internal hairs in the intercellular canals of Brasenia in 1884.

The structure of the sheaths at the tips of the rootlets (very different from ordinary rootcaps) and their origin. Anatomy of rootstock, runners, stems and petioles. (Total absence of vessels and other lignified tissue in the internodes. The peculiar mode of connection between the intercellular canals of the mestoms of two contiguous internodes). The petiole. The leaf (remarkable structure of the epidermis cells; water-pores on lower side). Submerged leaves, their structure.

The mucilage. Its origin from the hairs of the epidermis. Hairs described. The various reactions showing the formation and nature of the mucilage (bacteria living in it).

The internal hairs (probably pathological formations).

(Numerous microscopic slides verifying the statements of the paper were presented; also outline illustrations on chart, and living and herbarium specimens.)

THE CULTIVATED CINCHONAS OF BOLIVIA. By H. H. RUSBY, M.D., Columbia College, New York, N. Y.

[ABSTRACT.]

CINCHONA has not been studied in South America since its cultivation there has resulted in the production of new forms. These differ from the new forms produced in foreign plantations, as the stocks carried to those parts consisted of only the valuable species, while all species were planted in Bolivia. This paper, therefore, treats largely of new hybrid forms. The special conditions favoring hybridization there, are:

1. The tendency of this family to cross-fertilization.
2. Special organization,— dimorphism.
3. Aggregation into plantations.
4. Abundance of insects, continuous by day and night.
5. Humming-birds.

The difficulty of classifying the Cinchonas, which has led some to assert its impossibility, is partly due to the employment of certain characters which in this genus are not specific, and the neglect of others which in this genus are constant and valuable. Such non-specific characters are:

1. Chemical composition of bark.
2. Form of leaf without specifying stage of development.
3. Degree of pubescence.
4. Color of leaves.
5. Size and color of flowers.
6. Dimorphic condition of one species contrasted with a different dimorphic condition in another.
7. Form and appearance of pods without specifying stage of development.

Neglected characters are:

1. Venation.
2. Kind of pubescence.

The specimens found cultivated in Mapiri, Bolivia, are:

C. Calisaya, Wedd.
" " " var. *microcarpa*, Wedd.
" " " " *Ledgeriana*.
" *micrantha*, Wedd.
" *ovata* (two species described under this name).
" *amygdalifolia*, Wedd.
" *lanceolata*, R. & P.
" *lancifolia*, Mutis (a form of *C. Calisaga*).

The hybrids found in my collection are:

C. Calisaya × *C. ovata*, five numbers.
" " × *C. amygdalifolia*, four numbers.
" " var. *microcarpa* × *C. ovata*, one number.
" " " " × *C. amygdalifolia*, two numbers.
" *C. ovata* × *C. amygdalifolia*, two numbers.

Doubtful forms are a hybrid, each of
C. micrantha × *C. ovata*.
C. micrantha × *C. amygdalifolia*.

Character of the injuries produced by parasitic Fungi upon their host plants. By A. B. Seymour, Harvard University, Cambridge, Mass.

[Abstract.[1]]

Parasitic Fungi injure their host plants:—

(1) By taking their nutriment and causing, to some extent, starvation. Individual cells are killed or their food-supply continually absorbed by mycelium or haustoria. Cell walls are injured.

[1] The entire paper is to appear in the American Naturalist for Dec., 1887.

(2) The power of assimilation is impaired. Reduction of food-supply weakens the physiological power. Chlorophyll is destroyed in some cells. Spots are formed. Black molds obstruct passage of light to the chlorophyll. Some fungi cause a change of position in the host and less favorable exposure.

(3) Growth is abnormally accelerated or retarded, causing distortions as well as impaired vitality.

(4) Any parts may be affected; chlorophyll-bearing parts most frequently, but also roots, as cabbage roots by *Plasmodiophora Brassicæ*, and stems, as of *Prunus* by *Sphæria modosa*, and cedar by *Gymnosporangia*.

In the flowers of blackberry a species of *Fusisporium* causes the distortion known as "double blossom"; in many grasses, the entire inflorescence is destroyed, as that of *Panicum sanguinale* by *Ustilago Rabenhorstiana*. *Ustilago antherarum* infests anthers of *Caryophyllaceæ*. The ovary of *Prunus* is converted into a pouch by *Exoascus Pruni;* that of rye into a horn-like body by *Claviceps;* that of the pear is killed by *Fusicladium* and falls from the tree. *Tilletia caries* destroys the seeds of wheat.

(5) Decay is produced in ripe fruits, affecting their appearance or quality or destroying them. The parasite may continue its growth under conditions like those accompanying saprophytic growth.

(6) Valuable plants become infested with diseases from less valuable ones, as when *Peronospora* spreads from wild grapes or *Ampelopsis* to cultivated grapes, or wild cedars infest apple trees with rust. This offers a favorable field for further investigation.

The extent of the injury attributable to any one cause is difficult to determine, as several act together.

Canada thistle, attacked by *Puccinia suaveolens*, wilts in hot sunshine, probably from exhaustion of food-supply. *Puccinia graminis* produces greater injury in its teleuto-stage than in its uredo-stage for the same reason.

On the structure of the frond in Champia parvula Harv. By Robert P. Bigelow, Washington, D. C.

[ABSTRACT.]

The results here presented are derived from work done last winter in the cryptogamic laboratory at Harvard College. The material was alcoholic, and was studied partly by freehand sectioning, but chiefly by embedding in paraffine and sectioning on a Thoma microtome. A modification of the chloroform method was employed in embedding.

Champia parvula Harv. was taken for study because it is a representative of the peculiar group of *Florideæ*, having hollow fronds. The frond of *C. parvula* is cylindrical, jointed and branched. Cut longitudinally, it is seen to be divided into barrel-shaped chambers by diaphragms at the joints. In each branch there is a variable number of simple filaments

each composed of a single row of elongated cells. These filaments run close to the wall of the frond or cortex, from the tip to the base of the branch and pierce the diaphragms unchanged. The filaments in the secondary branches are not continuous with any of those in the primary branches. Most of the cells of the filaments, except those cells that penetrate the diaphragms, bear, near the middle on the side away from the cortex, a small, rounded *bulb cell*. Opposite this bulb cell there is often a cell connecting the filament to the cortex. The cortex and diaphragm are single-layered.

At the tip of each branch, instead of a single apical cell, there is a cluster of such cells, corresponding exactly in number and position to the filaments of the branch. From time to time, each apical cell gives off by division a cell from the side away from the apex. This cell divides into an outer and an inner cell. The outer cell, by further division, helps to form the cortex. The inner cell joins a row of similar cells to form a longitudinal filament. It may divide a few times parallel to the cortex. If it divide but once, the result is a bulb-cell; if several times, conjointly with corresponding cells in the other filaments, a diaphragm results.

The principal conclusions are; that, each of the longitudinal filaments is headed, morphologically, by an apical cell from which the cells of the filaments and of a corresponding area of the cortex are derived, and that the diaphragms and bulb-cells are alike in arising by outgrowths from the filaments near the tip of the frond.

[For a more complete account see Proc. Amer. Acad. of Arts and Sciences, Vol. XXIII, pp. 111-121.]

THE FLORA OF THE POTOMAC FORMATION IN VIRGINIA. By Prof. WILLIAM M. FONTAINE, University of Virginia, Va.

[ABSTRACT.]

THE name Potomac formation has been applied to a series of newer mesozoic sands, gravels and clays, sometimes cemented into sandstones and conglomerates, which appear along the inner margin of the coastal plain, forming the basal member of the undisturbed mesozoic and cenozoic formations of the eastern United States, in Virginia, Maryland, Delaware and perhaps other states. It comprises two members — an upper, consisting generally of variegated clays which are well exposed about Baltimore, and a lower, consisting predominantly of sands and gravels, well-exposed in the bluffs of the Potomac river below Washington. The upper member is known only north of Fredericksburg, and the lower is best developed from Washington to Richmond. The life of the upper member is not well known, and the present paper deals only with the sparse animal remains and abundant plant fossils of the lower member.

The animal remains include a fish, not yet identified, and three or four species of *Estheria*.

The plant impressions are exceedingly abundant and well preserved. No fewer than 375 species have been collected and identified, or described and drawn; and of these more than 300 are new to science. The flora is a complex one and represents the period of transition from the early polycotyledonous type to the dicotyledonous type which has ever since remained the predominant one. There is a large number of Jurassic forms, but these are associated with a still larger number of forms which survived in and even through the Cretaceous.

The age of the formation, as indicated by its flora, appears to coincide approximately with that of the Lower and Middle Neuronian of Greenland and Europe. This testimony of the plants consists fairly with the stratigraphy of the formation, which is evidently post-Rhœtic and is unconformably overlain by the New Jersey Cretaceous.

METHODS OF BRANCHING IN THE FIBRO-VASCULAR SYSTEM OF PLANTS. By A. A. CROZIER, U. S. Department of Agriculture, Washington, D. C.

[ABSTRACT.]

THE structural study of plants has related more to the histology of the tissues than to their distribution and comparative form. Of the three systems of tissues usually distinguished in the higher plants, the fibro-vascular is most closely connected with their plan of growth. This system first appears in mosses, where it is never more than a few vessels at the centre of the stem. In ferns, it is well developed and assumes a great variety of forms, usually appearing as a ring of separate bundles, but in some of the higher genera as a ring of united bundles. In lycopods, the system is here regarded as a crowded and partially consolidated ring of bundles. In endogens, the inner bundles surround a central pith, while the remaining bundles are believed to be formed at the same time or later in similar surrounding tissue.

Two leading methods of branching in the fibro-vascular system were described. In the first the fibro-vascular ring of the stem divides, a part being deflected to the lateral member without change—illustrated by most ferns, as Asplenium, and by the branches of many flowering plants. In the second method the parts going to the lateral member originate at the centre of single bundles, or of fibro-vascular centres—illustrated by the leaf in Osmunda, Equisetum, Lycopodium, and many flowering plants.

The honey-plant. By Mrs. F. S. Pease, Buffalo, N. Y.

[ABSTRACT.]

This plant was identified by Dr. Beal, and Mr. Scribner, as *Echinops Sphærocephalus*, a perennial, and native of Central France. It was first introduced and successfully grown in this country by Mr. H. Chapman of Versailles, New York, six years ago. It did not bloom the first year, but the second and third years he obtained from seed spherical blossoms of a fragrant odor, which proved an irresistible attraction to all the bees in the neighborhood. From the small beginning, Mr. Chapman has this year ten acres in full bloom. The seed should be gathered as soon as the balls turn brown, and when ripe the seed can easily be shaken from the balls. The plant grows from four to five feet high, with large prickly leaves, which with the stalk resemble those of the thistle. The blossoming is in accordance with the thrift of the plant, the soil, and the season. It consists of ten to thirty spherical shaped heads, from one and one-half to two inches in diameter, and very productive of nectar. The heads all stand upright, and are round like a ball, the entire surface being covered with white flowers bearing bluish stamens. The flowerets on the top of the sphere open first, and then these along the sides; the opening continuing in the order of nature around the surface of the spherical head; the last flowerets opening near to the stem after the blossoms on the top of the heads have faded and the seed capsules of the first blossoms have hardened. The seeds are in weight and appearance very much like the grains of rye, are enclosed in a capsule, and fall directly to the ground, unlike those of the thistle, which may be blown away.

The length of time from the first appearance of the blossoms until the falling of the first blossom is about eight days, but the heads or balls, sent out from individual shoots forming clusters, vary in age and size; so that the honey-bearing is continued from twenty to thirty days. The season and length of time of blossoming may be extended by cutting back portions of the plant, thereby forming fresh blossoms and supplies. The plant is hardy, easily propagated and grows in any soil, even clay if not too wet, in which case it will leaf out the same as wheat or other crops. It can be planted in waste places, in drill, or on hill-sides like cotton seed, and seems to take possession of the soil, exterminating all weeds and other vegetation. The plant has been grown in various soils throughout the United States and Canada during the last two years, and in all cases successfully.

Its value to the honey-producer seems beyond all question, as by *actual count* the number of bees that visited a single head from 5 o'clock A. M. to 7 o'clock P. M. was *two thousand one hundred and thirty-five*, the blossoms of one plant of thirty heads furnishing supplies for over sixty-four thousand bees.

In 1886, in an apiary of some 149 colonies, the bees made an excellent showing in the hives from this plant, all other resources for honey gathering being destroyed by the severe drought. The honey in all cases is pronounced of superior quality.

PRODUCTS FROM THE HONEY-PLANT SEED. By F. S. PEASE, Buffalo, N. Y.

[ABSTRACT.]

THE seed was obtained from the honey-plant grown by H. Chapman. This seed yields an oil of peculiar properties, of pleasant odor, and not unpleasant taste.

There are about 27,000 honey-plant seeds in one pound, and one pound of this seed, even when pressed in a crude way, yields four and one-quarter to four and one-half ounces of oil, a *single grain* of seed, pressed in a pair of pincers showing the yield of oil.

Compared with linseed, the commercial weight of which is fifty-six pounds to the bushel, the yield is two gallons of oil, or twenty-eight pounds to one gallon of 120 ounces. Twenty-eight pounds of the honey-plant seed with improved crushers, should yield four and one-half ounces to the pound, or 126 ounces against 120 ounces of linseed.

The specific gravity of the honey-plant oil is $21\frac{3}{4}°$. Beaume linseed oil being 20° and unbleached cotton-seed oil 22°.

The oil shows no acid-reaction after an exposure of twelve months to the air, and resembles poppy-seed oil in many respects with far less viscosity than either poppy or rape-seed oil. The flash and fire test show wonderful results, and are very high, but few oils equalling it.

The first flash occurred at 545° F. and a very light flash compared with other oils, every five degrees to 615° F. the fire test,— but not permanent, boiling lightly at 600° F. At this high test, the boiled oil changes color to a dark garnet, but unlike linseed oil, which becomes a varnish, the odor still remained pleasant at this heat. It stands a test of zero — 0° cold without change.

From the crude experimental test made, we are led to believe that this new oil from the honey-plant seed possesses a commercial value equal to any of the seed oils, and superior to many, and we expect to see it classed as a burning, a lubricating and a salad oil for culinary uses, also for artists' and painters' use. The residuum, or cake, left after the oil has been pressed out, seems to possess a medicinal property of some kind. To the taste, it is intensely bitter like quinine. At present we do not know what its medicinal properties are. Linseed produces two products, both valuable, the oil and the cake. The honey-plant seed, two also, that may prove as valuable, a nectar for the bees, and a new-oil, and also a third product from the residuum after the oil is extracted, which we believe will prove a very important one, and be of more value than either nectar or oil.

The literature on the plant is very meagre, it being mentioned only in a French botanical work published in 1882, one year later than the discovery of the plant in this country, and there is no mention of its being an oil-bearing plant.

SOME NOTES ON AMERICAN ROSES. By SERENO WATSON, Botanic Garden, Cambridge, Mass.

THE paper consisted of a brief characterization of the species of North American roses.

A COMPARISON OF THE EPIDERMAL SYSTEM OF PLANTS. By Prof. W. J. BEAL, Agricultural College, Mich.

NOTES ON THE CATALPA LEAF-SPOT DISEASE. By EFFIE A. SOUTHWORTH, Forestville, N. Y.

THE FLORA OF THE AMBOY CLAYS. By Prof. J. S. NEWBERRY, Columbia College, New York, N. Y.

[The substance of this paper is given in the Bulletin of the Torry Botanical Club, for March, 1886.]

A STUDY OF SILPHIUM PERFOLIATUM AND DIPSACUS LACINIATUS IN REGARD TO INSECTS. By Prof. W. J. BEAL, and C. E. ST. JOHN, Agricultural College, Mich. [Printed in full in Botanical Gazette for November, 1887.]

MORPHOLOGY OF THE LEGS OF HYMENOPTEROUS INSECTS. By Prof. A. J. COOK, Agricultural College, Mich.

ON THE MORPHOLOGY OF THE SKULL, AND THE EVOLUTION OF THE ICHTHYOPTERYGIA. By Dr. GEORGE BAUR, New Haven, Conn.

ON THE MORPHOLOGY OF THE RIBS. By Dr. GEORGE BAUR, New Haven, Conn.

SECTION H.

ANTHROPOLOGY.

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ADDRESS

BY

DANIEL G. BRINTON, M.D.,

VICE PRESIDENT, SECTION H.

A REVIEW OF THE DATA FOR THE STUDY OF THE PREHISTORIC CHRONOLOGY OF AMERICA.

EARLY in this century the doubt was expressed by Alexander von Humboldt whether it is philosophical to inquire into the origin of any of the human races or sub-species. Although he expressed this doubt with particular reference to the American race, I believe I am right in assuming that the hesitancy he felt in pushing inquiry so far, should now disappear in view of new methods of research and a wider range of observations on which to found opinions. We may not, in fact we shall not, be able to trace the American or any other sub-species directly back to its origin in place or time; but by reviewing all the data which have been offered in solution of such a problem, we may perceptibly narrow the question, and also estimate the relative value of the means proposed. It is to such a review, applied to the American race, that I now invite your attention.

The prehistoric antiquity of America dates back from the exploration of the continent by the Europeans. It is therefore not the same in all parts; but in this respect we merely follow the analogy of European archæology, which also is obliged to begin its studies of prehistoric times from different dates. A savage tribe enters history when its records first become preserved in writing, and all time anterior is its prehistoric period. To reconstruct the story of its life, its growth, its migrations and actions during the indefinitely long lapse of years before it appears in history is the task of the archæologist. I propose to examine, so far as this task refers to America, what means have been suggested for accomplishing it, and what they are worth. In such a wide survey you must pardon the unavoidable superficiality of treatment.

The data upon which theories of the antiquity, the genealogy and the affinities of this race have been constructed are varied. For convenience of treatment I shall class them under six heads. They are:

I. *Legendary*, including the traditions of the native tribes and their own statement of their history.

II. *Monumental*, where we have to do with those structures whose age or character seems to throw light on the question.

III. *Industrial*, under which heading we may inquire as to the origin of both the useful and the decorative arts in the New World.

IV. *Linguistic*, broaching the immense and important questions as to the diversity and affinities of languages.

V. *Physical*, which takes into consideration the anatomic and morphologic peculiarities of the American race; and finally

VI. *Geologic*, where its position in the geologic horizons is to be determined, and the influence upon it of the physical geography of the continent.

Legendary. Turning to the first of these, the legendary data, I confess to a feeling of surprise to discover that very learned scholars should still hold to the opinion that the native tribes, even some of the most savage of them, retain to this day traditions which they had brought from their supposed Asiatic homes. Thus the learned missionaries, Bishop Henry Faraud and the Abbé Emile Petitot, both entirely familiar with the Cree and the Athapaskan languages and lore, insist that the myths and legends of these tribes bear such strong resemblances to the Semitic traditions that both must have had a common origin. No one can deny the resemblance; but the scientific student of mythology discovers such identities too frequently and at points too remote, to ask any other explanation for them than the common nature of the human mind.

The question has been often raised how long a savage tribe, ignorant of writing, is likely to retain the memory of past deeds. From a great many examples in America and elsewhere, it is probable that the lapse of five generations, or say two centuries, completely obliterates all recollection of historic occurrences. Of course, there are certain events of continuous influence which may be retained in memory longer: for example, the federation of prominent tribes; and perhaps a genealogy may run back farther. My learned friend, Dr. Boas, informs me that some tribes on Vancou-

ver's Island pretend to preserve their genealogies for twelve or fifteen generations back; but he adds that the remoter names are clearly of mythical purport.

It appears obvious that all efforts to establish a prehistoric chronology on the legends of savage tribes, are and must be vain.

The case is not much better with those semi-civilized American nations, the Mayas and Nahuas, who possessed a partially phonetic alphabet, or with the Quichuas, who preserved their records by the ingenious device of the quipu. Manco Capac, the alleged founder of the Peruvian state, floats before us as a vague and mythical figure, though he is placed in time not earlier than the date when Leif the son of Eric anchored his war-ship on the New England coast. Historians are agreed that the long lists of Incas in the pages of Montesinos, extending about two thousand years anterior to the Conquest, are spurious, due to the imagination or the easy credulity of that writer.

The annals of Mexico fare no better before the fire of criticism. It is extremely doubtful that their earliest reminiscences refer to any event outside the narrow valley parcelled out between the petty states of Tenochtitlan, Tezcuco, and Tlacopan. The only fact that bears out the long and mysterious journey from the land of the Seven Caves, Chicomoztoc, in the distant northwest, by the great water, is that the learned and indefatigable Buschmann has conclusively shown that the four languages of Sonora and all the dialects of the Shoshonian family reveal marks of continued and deep impressions of the Nahuatl tongue. But the chronicles of Mexico proper contain no fixed date prior to that of the founding of the city of Tenochtitlan, in the year 1325 of our era.

I am aware that there are still some writers who maintain that both the Mexican and the Maya astronomic cycles assume a commencement for their records centuries, even thousands of years, before the beginning of our era. These opinions, however, have not obtained the assent of other students. We are too ignorant both of the astronomy and the methods of writing of these nations to admit such claims; and the facts advanced are capable of quite other interpretation.

It is, on the whole, rare for the American tribes to declare themselves autochthonous. The Mayas, on the peninsula of Yucatan, stated that their earliest ancestors came there from beyond the seas, some from the far east, others from the west. So the Toltecs,

under Quetzalcoatl, were fabled to have entered Mexico from beyond the Eastern Ocean. The Creeks and Choctaws pointed to the west, the Algonkins generally to the east, as their primal home. These legends are chiefly mythical, not much truer than those of other tribes who claimed to have climbed up from some underworld. Sifting them all, we shall find in them little to enlighten us as to the prehistoric chronology of the tribes, though they may furnish interesting vistas in comparative mythology.

That in which we may expect the legends of tribes to be of most avail is their later history, the record of their wars, migrations and social development within a few generations. The spirit of the uncivilized man is, however, very careless of the past. We have means of testing the exactness of such traditions in some instances, and the result is rarely such as to inspire confidence in verbal records. Those of you who were present at the last meeting will remember how diversely two able students of Iroquois tradition estimated its value. Even when remarkable events are not forgotten, the dates of their occurrence are generally vague. The inference, therefore, is that very few data, dependent on legendary evidence alone, can be accepted.

Monumental. When we turn to the monumental data, to the architecture and structural relics of the ancient Americans, we naturally think first of the imposing stone-built fortresses of Peru, the massive pyramids and temples of Yucatan and Mexico, and the vast brick-piles of the Pueblo Indians.

It is doubtful if any of these notable monuments supply prehistoric dates of excessive antiquity. The pueblos, both those now occupied and the vastly greater number whose ruins lie scattered over the valleys and mesas of New Mexico and Arizona, were constructed by the ancestors of the tribes who still inhabit that region, and this at no distant day. Though we cannot assign exact dates to the development of this peculiar civilization, there are abundant reasons, drawn from language, physical geography and the character of the architecture, to include all these structures well within the period since the commencement of our era.

There is every reason to suppose that the same is true of all the stone and brick edifices of Mexico and Central America. The majority of them were occupied at the period of the Conquest; others were in process of building, and of others the record of the date of their construction was clearly in memory and was not

distant. Thus, the famous temple of Huitzilopochtli at Tenochtitlan, and the spacious palace — or, if you prefer the word "communal house" — of the ruler of Tezcuco, had been completed within the lifetime of many who met the Spaniards. To be sure, even then there were once famous cities fallen to ruin and sunk to oblivion in the tropical forests. Such was Palenque which could not have failed to have attracted the attention of Cortés had it been inhabited.

Such also was T'Ho, on the site of the present City of Mérida, Yucatan, where the earliest explorers found lofty stone mounds and temples covered with a forest as heavy as the primitive growth around it. But tradition and the present condition of such of these old cities, as have been examined, unite in the probability that they do not antedate the conquest more than a few centuries.

In the opinion of some observers, the enigmatical ruins on the plain of Tiahuanaco, a few leagues from the shore of Lake Titicaca, in Peru, carry us far, very far, beyond any such modern date. "Even the memory of their builders," says one of the most recent vistors to these marvellous relics, General Bartolomé Mitre, "even their memory was lost thousands of years before the discovery of America."

Such a statement is neither more nor less than a confession of ignorance. We have not discovered the period nor the people concerned in the ruins of Tiahuanaco. It must be remembered that they are not the remains of a populous city, but merely the foundations and beginnings of some vast religious edifice which was left incomplete, probably owing to the death of the projector or to unforeseen difficulties. If this is borne in mind, much of the obscurity about the origin, the purpose and the position of these structures will be removed. They do not justify a claim to an age of thousands of years before the Conquest; hundreds will suffice. Nor is it necessary to assent to the opinion advanced by General Mitre, and supported by some other archæologists, that the most ancient monuments in America are those of most perfect construction, and, therefore, that in this continent, there has been, in civilization, not progress but failure, not advance but retrogression.

The uncertainty which rests over the age of the structures at Tiahuanaco is scarcely greater than that which still shrouds the origin

of the mounds and earthworks of the Ohio and Upper Mississippi valleys. Yet I venture to say that the opinion is steadily gaining ground that these interesting memorials of vanished nations are not older than the mediæval period of European history. The condition of the arts which they reveal indicates a date that we must place among the more recent in American chronology. The simple fact that tobacco and maize were cultivated plants is evidence enough for this.

There is, however, a class of monuments of much greater antiquity than any I have mentioned. These are the artificial shell-heaps which are found along the shores of both oceans and of many rivers in both North and South America. They correspond to the kitchen-middens of European archæology.

In several parts of the continent they have been examined by competent observers and the question of their antiquity approximately ascertained. I need not say this differs widely, for these refuse heaps of ancient villages or stations were of course begun at wide intervals. Those along the coast of Maine, as reported upon by Prof. Jeffries Wyman, did not yield the bones of any extinct animal, although the presence of the remains of the great auk, now found only in the arctic regions, speaks for a condition of climate different from that obtaining at present. There is one fact, however, which must be borne in mind in examining the shell-heaps of Maine and of other localities immediately bordering the ocean. The shores of that state have been steadily yielding to the encroachment of the waves, and therefore the most ancient shell-heaps may reasonably be supposed to have been washed away.

The same observer, Professor Wyman, assigns a vastly greater age to the maritime shell-heaps of Florida.

Further to the south, in Costa Rica, Dr. Earle Flint has examined the extensive artificial shell deposits which are found along the shores of that republic. They are many feet in height, covered by a dense forest of primeval appearance, and are undoubtedly of human origin. He does not hesitate to assign to them an age of 20,000 years, but I have not learned whether they contain the remains of extinct species.

In Brazil such shell-heaps are called *sambaquis,* and they are of frequent occurrence along the bays and inlets of the coast. Some of them are of extraordinary dimensions, rising occasionally to more than a hundred feet in height. The lower layers have been

consolidated into a firm, stony breccia of shells and bones, while the surface stratum, from six to ten feet thick, is composed of sand and vegetable loam, supporting a growth of the largest trees. Yet even the lowest layers of this breccia, or shell-conglomerate, yield tokens of human industry, as stone axes, flint arrowheads, chisels, and fragments of very rude pottery, as well as human bones, sometimes split to extract the marrow. The shells are by no means all of modern type. Many are of species now wholly extinct, or extinct in the locality. This fact alone carries us back to an antiquity which must be numbered by many thousands of years before our era. At that remote period not only did a fishing and hunting race dwell along the Brazilian coast, but this race was fairly advanced on the path to culture, it was acquainted with pottery, with compound implements, and with the polishing of stone. We further know that this race was not that which occupied the land when the whites discovered it; for the human skulls disinterred from the sambaquis are, craniologically, almost diametrically opposite those of the Botocudos and the Tupis. Yet if we can trust the researches of Dr. Lund in the caverns of Brazil, the oldest skulls in these deposits, found in immediate connection with the bones of extinct mammalia, belonged to the ancestors of these tribes. Markedly dolichocephalic, they present an entire contrast to the brachycephalic type from the sambaquis.

This class of monuments, therefore, supply us data which prove man's existence in America in what some call the diluvial, others the quaternary and others again the pleistocene epoch, that characterized by the presence of extinct species.

Industrial. Let us now turn to the industrial activity of the American race, and see whether it will furnish us other data concerning the prehistoric life of the New World. We may reasonably look in this direction for aid, since it is now universally conceded that at no time did man spring into being fully armed and equipped for the struggle for existence, but everywhere followed the same path of painful effort from absolute ignorance and utter feebleness to knowledge and power. At first, his only weapons or tools were such as he possessed in common with the anthropoid apes: to wit, an unshapen stone and a broken stick. Little by little, he learned to fit his stone to his hand and to chip it to an edge, and with this he could sharpen the end of his stick, thus providing himself with a spear and an axe.

It was long before he learned to shape and adjust the stone to the end of the stick, and to hurl this by means of a cord attached to a second and elastic stick, in other words, a bow; still longer before he discovered the art of polishing and boring stones and fashioning clay into vessels. These simple arts are landmarks in the progress of the race: the latter divides the history of culture into the palæolithic or rough stone period; and the neolithic or polished stone period; while the shaping of a stone for attachment to a handle or shaft marks the difference between the period of compound implements and the early period of simple implements, both included in the older or palæolithic age. With these principles as guides, we may ask how far back on this scale do the industrial relics in America carry us?

I have spoken of the great antiquity of some of the American shell-heaps, how they carry us back to the diluvial epoch, and that of numerous extinct species. Yet it is true that in the oldest hitherto examined in Brazil, Guiana, Costa Rica and Florida, fragments of pottery, of polished stone, and compound implements occur even in the lowest strata. Venerable though they are, they supply no date older than what in Europe we should call the neolithic period. The arrowheads which have been exhumed from the loess of the ancient lakebeds of Nebraska, and the netsinkers and celts which have been recovered from the auriferous gravels of California, prove by their form and finish that the tribes who fashioned them had already taken long strides beyond the culture of the earlier palæolithic age. The same is true, though in a less degree, of the chipped stones and bones which Ameghino exhumed from the lacustrine deposits of the Pampas, although he proves that these relics were the products of tribes contemporary with the extinct glyptodon and mylodon, as well as the fossil horse and dog. In the very oldest station which he examined, there appears to have been found a quartz arrowhead; yet he argues that this station dated from the pliocene division of the tertiary, long anterior to the austral glacial epoch. This leaves another such open conflict between geology and the history of culture, as Professor Rau has already pointed out as existing in Californian archæology.

The only station in America which has furnished an ample line of specimens, and among them not one, so far as I know, indicating a knowledge of compound implements, is that of the Trenton gravels, New Jersey. There alone do we appear to be in face

of a stage of culture as primitive as that of the stations of Chelles and St. Acheul, in France, absolutely without pottery, without polished stone, without compound implements.

Assuming that these post-glacial gravels about Trenton supply us the earliest authentic starting point in the history of culture on this continent, the later developments of industry will furnish us a number of other data. This first date was long before the extinction of the native American horse, the elephant, the mammoth, and other animals important to early man. There is nothing unlikely therefore in the reported discoveries of his pointed flints or his bones in place along with the remains of these quadrupeds; nor would it be surprising to find that he had scratched rudely their outlines on stones or bones, or imitated their forms in his utensils as did the savages of La Madeleine. There is no *a priori* argument against mastodon mounds or pipes; their authenticity is merely a question of evidence.

In a recent essay, Dr. Richard Andree has shown by a wide collation of instances how readily even the least cultured savages turn to an imitation of natural objects by lines and colors. Drawing and painting were among the earliest acquisitions of man. Paint-pots and scratched bones are exhumed from deposits of the reindeer age in Europe, and in America scarcely a tribe but exhibited a taste for such amusements.

It is not enough to stop by proving this. In these childish markings we note the infancy of the arts of sculpture and painting. They contain the first chapters of the history of the æsthetic senses, of the effort to body forth in representations the conceptions of the mind. To the extent that they display an appreciation of organic symmetry of form, and an approach toward the ideally beautiful, they reveal those subtle and delicate perceptions which lead up to the highest levels of art.

I should like to emphasize this point, because collectors and archæologists are inclined to limit their attention to the relative degrees of mere technical skill displayed in the products of industry. There may, however, be really wonderful technical skill with a total absence of the idea of the beautiful. Yet as a test of national psychical endowments, the latter is infinitely the more indicative. Compare one of those figurines from Tenagra in Bœotia with a Chinese god elaborately chiselled from ivory or bronze: the one is a hurriedly moulded toy of clay, the other the labor of

painful years; but the former reveals a potentiality in the nation which designed it far beyond the possibilities of the latter. In prehistoric art the germs of the sense of symmetry, of ideal beauty, in outline and form, offer us data by which we can measure the psychical development of tribes more accurately than by any other objective test.

Not only the form but the material of implements supplies us data. If man in his earliest stages, was, as some maintain, quite migratory, it is certain that he did not carry his stone implements with him, nor did he obtain by barter or capture those of other tribes. All the oldest implements are manufactured from the rocks of the locality. When, therefore, we find a weapon of a material not obtainable in the vicinity, we have a sure indication that it belongs to a period of development considerably beyond the earliest. When the obsidian of the Yellowstone Park is found in Ohio, when the black slate of Vancouver's Island is exhumed in Delaware, it is obvious we must assume for such extensive transits a very noticeable æsthetic and commercial development. But what shall we say when the jade of an implement from Central America is pronounced identical with that from Central China, or the copper of a chisel from Ohio is asserted to have been derived from Peru? We must hold our judgment in suspense till this identity is proved.

I can but touch in the lightest manner on the data offered by the vast realm of industrial activity. The return it offers is abundant, but the harvesting delicate. In the dissemination of certain arts, certain inventions, certain decorative designs and æsthetic conceptions from one tribe to another, we have a most valuable means of tracing the prehistoric intercourse of nations: but we must sedulously discriminate such borrowing from the synchronous and similar development of independent culture under like conditions.

In one department of industry we shall be largely free from this danger, that is, in the extension of agriculture. One of America's ablest ethnologists, Dr. Charles Pickering, as the result of a lifetime devoted to his science, finally settled upon the extension of cultivated plants as the safest guide in the labyrinth of prehistoric migrations. Its value is easily seen in America when we reflect that the two tropical plants, maize and tobacco, extended their area in most remote times from their limited local habitat about the Isthmus of Tehuantepec to the north as far as the St. Lawrence

river and to the south quite to the Archipelago of Chiloe. Their presence is easily traced by the stone- or earthen-ware implements required for their use. How many ages it must have required for these plants to have thus extended their domain amid hostile and savage tribes through five thousand miles of space!

The squash, the bean, the potato and the mandioca are native food plants offering in a less degree similar material for tracing ancient commerce and migration. Humboldt and others have claimed as much for the banana (*Musa paradisiaca*), but the recent researches of Dr. Karl von den Steinen have removed that valued fruit from the list of native American plants. Both species of banana (*M. paradisiaca* and *M. sapientium*) were undoubtedly introduced into the New World after the discovery. Indeed, summing up the reply to an inquiry which has often been addressed to the industrial evolution of the indigenes of our continent, I should say that they did not borrow a single art or invention nor a single cultivated plant from any part of the Old World previous to the arrival of Columbus. What they had was their own, developed from their own soil, the outgrowth of their own lives and needs.

Linguistic. This individuality of the race is still more strongly expressed in their languages. You are all aware that it is upon linguistic data almost exclusively that American ethnology has been and must be based. The study of the native tongues becomes therefore of transcendent importance in the prehistoric chronology of the Continent. But to obtain its best results, this study must be conducted in a much more thorough manner than has hitherto been the custom.

In America we are confronted with an astonishing multiplicity of linguistic stocks. They have been placed at about eighty in North and one hundred in South America. It is stated that there are that many radically diverse in elements and structure. To appreciate the vista in time that this fact opens to our thoughts, we must recognize the tenacity of life manifested by these tongues. Some of them have scores of dialects spoken by tribes wandering over the widest areas. Take the Athapascan or Tinné, for example, found in its greatest purity amid the tribes who dwell on the Arctic sea, and along the Mackenzie river, in British America, but also the tongue of the Apaches who carried it almost to the valley of Mexico. The Algonkin was spoken from Hudson Bay

to the Savannah river and from Newfoundland to the Rocky Mountains. The Guarani of the Rio de la Plata underlies dialects which were current as far north as Florida.

How, then, in spite of such tenacity of American languages have so many stocks come into existence? This was the question which my predecessor in this chair last year undertook to answer. His suggestions appear to me extremely valuable, and only in one point do I widely differ from him, and that is, in the length of time required for these numerous tongues to be originated, to sever into dialects and to be carried to distant regions. According to the able linguist, Doctor Stoll, the difference which is presented between the Cakchiquel and Maya dialects could not have arisen in less than two thousand years; and any one who has carefully compared the earliest grammars of an American tongue with its present condition will acknowledge that the changes are surprisingly few. To me the exceeding diversity of languages in America and the many dialects into which these have split, are cogent proofs of the vast antiquity of the race, an antiquity stretching back tens of thousands of years. Nothing less can explain these multitudinous forms of speech.

Underlying all these varied forms of expression, however, I think future investigation will demonstrate some curious identities of internal form, traits almost or entirely peculiar to American languages, and never quite absent from any of them.

Such was the opinion of the two earliest philosophical investigators of these tongues, P. S. Duponaceau and Wilhelm von Humboldt. They called these traits *polysynthesis* and *incorporation*, and it was proposed to apply the term *incorporative* as a distinguishing adjective to all American languages. Of late years this opinion has been earnestly combatted by M. Lucien Adam and others; but my own studies have led me to adopt the views of the older analysts against these modern critics. I do not think that the student can compare any two stocks on the continent without being impressed with the resemblance of their expression of the relations of being, through the incorporative plan.

Along with this identity of plan, there coëxists the utmost independence of expression. An American language is usually perfectly transparent. Nothing is easier than to reduce it to its ultimate elements, its fundamental radicals. These are few in numbers and interjectional in character. The Athapascan, the

Algonkin, to whose wide extension I have already referred, have been reduced to half a dozen particles or sounds expressive of the simplest conceptions. Upon these, by combination, repetition, imitation and other such processes the astonishing structure of the tongue has been erected, every portion of it displaying the mechanism of its origin. It is this transparency which renders these tongues so attractive to the philosophic student of human expression, and so valuable to him who would obtain from them the record of the progress of the nation.

A thorough study of such a language would embrace its material, its formal and its psychologic contents. Its material elements include the peculiarities of its vocabulary: for example, its numerals and the system they indicate, its words for weights and measures, for color and direction, for relations of consanguinity and affinity, for articles of use and ornament, for social and domestic conditions and the like. Few studies of American languages go beyond this material or lexicographic limit; but in truth these are merely the externalities of a tongue, and have nothing to do with linguistic science proper. This concerns itself with the forms of the language, with the relation of parts of speech to each other and to the sentence, and with the historical development of the grammatical categories. Beyond this, again, is the determination of the psychical character of the tribe through the forms instinctively adopted for the expression of its thoughts, and reciprocally the reaction exerted by these forms on the later intellectual growth of those who were taught them as their only means of articulate expression.

These are data of the highest value in the study of prehistoric time, but so far as America is concerned, I could name but very few scholars who have pursued this promising line of research.

Physical. Much more attention has been paid to the physical than the linguistic data of the native Americans, but it may freely be said, with not more satisfactory results. This failure is partly owing to the preconceived notions which still govern the study of ethnology. Linnæus offered the cautious division of the human species into races named from the five great geographical areas it inhabited; Blumenbach pointed out that this roughly corresponded with the division into five colors, the white, black, yellow, brown and red races occupying respectively Europe, Africa, Asia, Polynesia and America. Unfortunately, Cuvier chose to simplify this

scheme, by merging the brown and red races, the Polynesian or Malayan and the American, into the yellow or Mongolian. The latest writers of the French school and I am sorry to add various Americans servilely follow this groundless rejection of the older scheme, and speak of Malayans and Americans alike as Mongolians or Mongoloids. Neither in language nor ethnic anatomy is there any more resemblance than between whites and Mongolians.

It is gratifying to see that the more accurate German investigators decidedly reject the blunder of Cuvier, and declare that the American race is as independent as any other of those named. Thus Dr. Paul Ehrenreich who has lately published an admirable monograph on the Botocudos of Brazil, a tribe often quoted for its so-called "mongoloid" aspect, declares that any such assertion must be contradicted in positive terms. Both in osteology and anatomy, in formation of the hair and shape of the skull, the differences are marked, permanent and radical.

What is true of the Botocudos is not less so of the other American tribes which are claimed to present Mongolian traits. Such assertions are based on the superficial observations of travellers, most of whom do not know the first principles of ethnic anatomy. This is sufficiently shown by the importance they attach to the oblique eye, a slight malformation of the skin of scarcely any weight.

The anatomy and physiology of the various American tribes present, indeed, great diversity, and yet, beneath it all, is a really remarkable fixedness of type. We observe this diversity in the shape of the skull, which may be, as among the Botocudos, strictly dolichocephalic, while the Araucanians are brachycephalic; the nasal index varies more than in the extremest members of the white race; the tint of the skin may be a dark brown with an under color of red, or of so light a hue that a blush is easily perceptible. The beard is usually absent, but D'Orbigny visited a tribe who wore it full and long. The height varies from an average of six feet four inches for adult males in Patagonia to less than five feet among the Warraus of Guiana; and so it is with all the other traits of the race. There is not one which is not subject to extensive variation.

On the other hand, these variations are not greater than can be adduced in various members of the white or black race. In spite of them all, there is a wonderful family likeness among tribes of American origin. No observer well acquainted with the type would err in taking it for another. Darwin says that the Fue-

gians so closely resemble the Botocudos that they seemed members of the same tribe. I have seen Arawacks from Guiana who in the northwest would have passed for Sioux.

In spite of the total dissimilarity of climate and other physical surroundings, the tribes of the tropics differ no more from those near the Arctic circle than they do among themselves. This is a striking lesson how independent of environment are the essential characteristics of a race, and it is a sweeping refutation of those theories which make such characteristics dependent upon external agencies.

A still more remarkable fact has been demonstrated by Professor J. Kollmann of Bâle: to wit, that the essential physical identity of the American race is as extended in time as it is in space. This accurate student has analyzed the cranioscopic formulas of the most ancient American skulls, those from the alleged tertiary deposits of the Pampas, those from the caverns of Lagoa Santa in Brazil, that obtained from Rock Bluff, Illinois, the celebrated Calaveras skull from California, and one from Pontemelo in Buenos Ayres of geologic antiquity. His results are most interesting. These very ancient remains prove that in all important craniologic indiciæ the earliest Americans, those who were contemporaries of the fossil horse and other long since extinct quadrupeds, possessed the same racial character as the natives of the present day, with similar skulls and a like physiognomy. We reach therefore the momentous conclusion that the American race throughout the whole continent, and from its earliest appearance in time, is and has been *one*, as distinct in type as any other race, and from its isolation probably the purest of all in its racial traits. This is a fact of the first order in establishing its prehistoric chronology.

Geologic. I have left the geologic data to the last as it is these which carry us with reasonable safety to the remotest periods. No one who examines the evidence will now deny that man lived in both North and South America immediately after the glacial epoch, and that he was the contemporary of many species of animals now extinct. As you are aware, the attempt has several times been made to fix the date for the final retrocession of the glaciers of North America. The estimates have varied from about 12,000 years ago up to 50,000, with a majority in favor of about 35,000 years.

There have also been various discoveries which are said to place

the human species in America previous to the appearance of the glaciers. Some remains of his industry have been reported from interglacial, others from tertiary deposits. Unfortunately, these finds have not been sufficient or not of a character to convince the archæologist. I have before adverted to the impossibility, for instance, of an archæologist accepting the discovery of a finely polished stone implement in a tertiary gravel, except as an intrusive deposit. It is a violent anachronism, which is without a parallel in other countries. Even the discovery of a compound implement, as a stemmed arrowhead, in strata of tertiary date, is, with our present knowledge, quite out of the question.

Although there are well recognized signs of glacial action in South America, it is not certain that the glacial epoch coincided in time in the two continents. That there was a reasonable approximation is probable from the appearance of later deposits. We may suppose therefore that the habitable area of the New World was notably less at that period and that the existing tribes were confined to a much narrower space. This would force them into closer relations, and tend powerfully to the production of that uniformity of type to which I have before referred.

We might also expect to discover in the tropical regions of America more frequent evidence of the primitive Americans than in either temperate zone. This has not been the case probably because the geologic deposits of the tropics have been less investigated. Throughout the West Indies there is an entire absence of palæolithic remains. Those islands were first peopled by tribes in the polished stone stage of culture. In the valley of Mexico human remains have been disinterred from a volcanic deposit of supposed tertiary age, and you have all heard of those human footprints which Dr. Earl Flint has unearthed in Nicaragua. These are found under layers of compact volcanic tufas, separated by strata of sand and vegetable loam. There can be no doubt of their human origin and of their great antiquity; but no geologist need be informed of the difficulty of assigning an age to volcanic strata, especially in a tropical country, subject to earthquakes, subsidence and floods.

It would not be in accordance with my present purpose to examine the numerous alleged finds of human remains in the strata of the tertiary and quaternary. All such furnish data for the prehistoric chronology of America, and should be carefully scrutinized by him who would obtain further light upon that chronol-

ogy. I must hasten to some other consideration which touch the remote events to which I am now alluding.

Since a comparison of the fauna of South America and Africa, and a survey of the sea-bottom between those continents have dispelled the dream of the ancient Atlantis, and relegated that land connection at least to the eocene period of the tertiary, no one can suppose the American man to have migrated from Africa or southwestern Europe. For other and equally solid reasons, no emigration of Polynesians can be assumed. Yet zoölogists, perfectly willing to derive man from an anthropoid, and polygenists to the utmost, hesitate to consider man an autochthon in the New World. There is too wide a gap between the highest monkeys and the human species in this continent. Discoveries of fossil apes might bridge this, but none such has been reported.

If we accept the theory that man as a species spread from one primal centre, and in the higher plasticity of his early life separated into well defined races which became unalterably fixed not much later than the close of the glacial epoch — and this theory appears to be that now most agreeable to anthropologists—then the earliest Americans made their advent on this continent as immigrants. This is our first fact in their prehistoric chronology; but before we can assign it an accurate position on the scale of geologic time we must await more complete discoveries than we now have at our command.

We must also wait until our friends, the geologists, have come to some better understanding among themselves as to what took place in the pleistocene age. You have heard me talking freely about the glacial epoch and its extension in America; but geologists are by no means of one mind as to this extension, and a respectable minority of them, led by Sir J. William Dawson, deny the existence or even possibility of any continental glacier. What others point out as a terminal moraine they explain to be "nothing but the southern limit of the ice-drift of a period of submergence."

It is clear that when we speak about the migration of the Americans at a time when the polar half of each continent was either covered with a glacier thousands of feet thick, or submerged to that depth beneath an arctic sea, we have to do with geographical conditions totally unlike those of to-day. I call attention to this obvious fact because it has not been obvious to all writers.

In your archæological reading you will rarely come across a

prettier piece of theoretical history than Mr. Lewis A. Morgan's description of the gradual peopling of the two Americas by tracing the lines of easiest subsistence. He begins at the fishy rivers of the northwest coast, and follows the original colony which he assumes landed at that point, all the way to Patagonia and Florida. But how baseless becomes this vision when we consider the geography of America as it is shown by geology to have been at a period contemporary with the earliest remains of man! We know to a certainty that the human race had already spread far and wide over both its continental areas before Mr. Morgan's lines of easiest nutrition had come into existence.

Properly employed, a study of those geologic features of a country which determine its geography will prove of vast advantage in ascertaining the events of prehistoric time. These features undoubtedly fixed the lines of migration and of early commerce. Man in his wanderings has always been guided by the course of rivers, the trend of mountain chains, the direction of ocean currents, the position of deserts, passes and swamps. The railroad of to-day follows the trail of the primitive man, and the rivers have ever been the natural highways of nations. The theories of Morgan therefore remain true as theories; only in their application he fell into an error which was natural enough to the science of twenty years ago. Perhaps when twenty years more shall have elapsed, the post-tertiary geology of our continent will have been so clearly defined that the geography of its different epochs will be known sufficiently to trace these lines of migration at the various epochs of man's residence in the western world, from his first arrival.

I have now set before you, in a superficial manner, it is true, the various sources from which we may derive aid in establishing the prehistoric chronology of America. I have also endeavored, to a limited extent, to express myself as to the relative value of these sources. None of them can be neglected, and it will be only from an exhaustive study of them all that we can expect to solve the numerous knotty problems, and lift the veil which hangs so darkly, on all that concerns the existence of the American race before the sixteenth century.

We are merely beginning the enormous labor which is before us; we have yet to discover the methods by which we can analyze fruitfully the facts we already know. But I look forward with the

utmost confidence to a rich return from such investigations. The day is coming and that rapidly, when the prehistoric life of man in both the New and the Old World will be revealed to us in a thousand unexpected details. We have but to turn backward about thirty years to reach a time when the science of prehistoric archæology was utterly unknown, and its early gropings were jeered at as absurdities. Already it has established for itself a position in the first rank of the sciences which have to do with the highest of problems. It has cast a light upon the pathway of the human race from the time that man first deserved his name down to the commencement of recorded history. Its conquests are but beginning. Year by year masses of new facts are brought to knowledge from unexpected quarters, current errors are corrected, and novel methods of exploration devised.

As Americans by adoption, it should be our first interest and duty to study the Americans by race in both their present and past development. The task is long and the opportunity is fleeting. A century more, and the anthropologist will scarcely find a native of pure blood; the tribes and languages of to-day will have been extinguished or corrupted. Nor will the archæologist be in better case. Every day the progress of civilization, ruthless of the monuments of barbarism, is destroying the feeble vestiges of the ancient race; mounds are levelled, embankments disappear, the stones of temples are built into factories, the holy places desecrated. We have assembled here to aid in recovering something from this wreck of a race and its monuments; let me urge upon you all the need of prompt action and earnest work, inasmuch as the opportunities we enjoy will never again present themselves in such fulness.

PAPERS READ.

ILLUSTRATIVE NOTES CONCERNING THE MINNESOTA ODJIBWAS. By Miss FRANC E. BABBITT, Coldwater, Mich.

[ABSTRACT.]

THE Odjibwas have many bands living upon reservations in northern Minnesota. The tribe is loosely subdivided upon a territorial basis, the Odjibwas speaking of themselves as Devil's Lake Indians, Red River Indians, Lake Superior Indians, etc. When a division occupies an extensive region, those Odjibwas congregating at particular points of it are distinguished as a band. Such are the Cass Lake, Mille Lacs, Leech Lake, White Earth, and Win-ni-bi-go-shish bands of Minnesota respectively. If large, the band has an ultimate segregation into settlements. Besides, it comprises an indefinite number of chieftaincies, each of which is ruled by its special civil chief. It has furthermore a cross division into totems or clans.

Civil Chieftaincies.

Let us instance particularly in Red Lake band living in the extreme north of the state, and seated about Red Lake, and along its feeders and outlet. This band, of something like 1200 Odjibwas all told, consists of seven chieftaincies, five of which are strictly hereditary while two are of modern formation, the chiefs of the latter having attained their position through influence acquired as so-called Headmen. However, one of these new-made rulers having died, his son succeeded to his dignities in the regular manner. The authority of the chief is based wholly in sentiment and convenience: there is no compulsion in the matter. Thus a disaffected or incommoded Red Laker may abandon his chieftaincy and enter another at option. The Red Lake chiefs of 1881 were named:—

May-*dway*-ga-no-nind (He-who-is-spoken-to), an aged man of excellent character and high standing among his people.

Little Rock, since dead, who united in his person the functions of grand-medicine-man and chief.

Little Thunder and Leading Feather, modern chiefs.

Crooked Arm, Praying Day, and Red Robe (Mois-ko-*ko*-nia).

War Chiefs.

There is no general civil chief of a band, a great division, or a tribe. This statement does not include the war chiefs. The Red Lake band was

in the days of its primal savagery under the leadership of a single war-chief. The last of these was May-zhuck-*ke*-osh (Falling Wind), who was reputed to have taken with his own hand no less than thirty-three Sioux scalps. He was of the Bear totem, to which alone the Odjibwas accorded the distinction of leading in war. Let it be observed, in passing, that, May-zhuck-*ke*-osh was the least possible like the ideal warrior of the books, having a diminutive person, delicate feet and hands, a pleasant face, a soft murmuring voice, and subdued manners. His leaden eyes, however, were altogether inscrutable.

Totems of the Red Lake Odjibwas.

The following is a list of the totems of the Red Lakers, as furnished the writer by Little Rock, aided by an educated Odjibwa lady who is at once thoroughly conversant with her tribal tongue, with English, and with the totem system.[1]

Bald Eagle	Eagle	Lynx	Snake
Bear	Eelpout	Marten	Sturgeon
Catfish	Elk	Mermaid	Wolf
Crane	Loon	Moose	Woodpecker.

A Rabbit totem and a River totem are also found among the Odjibwas, but it was the belief of Little Rock that no representatives of these were at that time, 1881, living at Red Lake.

The Bald Eagle and the Eagle are two quite distinct totems.

The Loon clan was formerly a large one here.

The Odjibwa historian, Mr. Wm. Warren, tells us that in olden times, when the civil polity of the tribe was much mixed up with their religious and medicinal rites, "the totem of the Mong (Loon) ruled over them, and Musk-wa, or Bear totem led them to war."

The Martens and next below them, the Bears, are held to be at present the two largest of the Red Lake clans.

The term Mermaid embodies an idea apparently so foreign to an aboriginal and especially to an inland tribe, that at first the writer refused to accept it as a correct exponent of the thing meant. However, Little Rock and Miss Warren insisted upon the name, declaring it to mean with the natives what it does with us. Whether the mermaid myth was indigenous or introduced remains to be decided; but it is stated by a missionary family named Ayer, who were stationed at Red Lake many years ago, that the Indians then considered it to be haunted by mythical creatures corresponding to the mermaids of civilized nations. There is no obvious reason, indeed, why a folk who people earth, water, and sky, habitually, with imaginary beings, might not invent fish-maidens for their fish-abounding lakes. The fact remains, nevertheless, that the idea may be a borrowed one.

The Red Lakers continue to abhor marriage between persons of the same totem, regarding it much like one between brother and sister. A

[1] See *Red Lake Notes*, Bulletin of the Minnesota Academy of Natural Sciences for 1881.

young son of May-zhuck-*ke*-osh once arranged a union with a daughter of Rocky Mountain, both of the Bear totem. To avoid effective opposition, the girl fled into the forest. The parents were inconsolable; community was horrified. Police finally restored the fugitive to the arms of her mother—in a very literal sense; for Mrs. Rocky Mountain soon reported at the agency, in scrap-English and unimpeachable pantomime, that she had beaten the bride-elect—beaten hard! beaten till the girl was good!

The Earth-Pits.

The Minnesota Odjibwas excavate earth-pits of two kinds; first such as are appropriated to domestic purposes; second, those designed for use in war. The first sort, like similar ones among the Dakotas, serve as receptacles for the storage of food. The lake Indians preserve their supplies of corn in granaries of this character. They are generally rectangular pits four or five feet in depth, having much the capacity of a large, deep trunk. Unlike the war-pits, they are formed with a certain degree of regularity. They have no facing, but when put to use are lined loosely with refuse material, like dried grass and flags, or discarded fragments of the rush mattings woven by the women. They are fashioned in some suitable spot out-of-doors and, when filled, are covered with soil and what not, arranged to present a natural appearance. These secreted supplies are probably of the same description with those buried in pilgrim days by Massachusetts Algonkins. Many of these Indians dismantle their summer lodges upon the shore, when the ice becomes too thick for the women to fish with gill-nets, and retreat for the winter to the shelter and unlimited fuel supply of the forest, while a family in which death has occurred, abandons and sometimes burns its dwelling; in both of which cases it is a convenience to have these little hoards quite distinct from the abode.

War-Pits.

The Odjibwa war-pits are irregular cavities scooped out with a design to protect or conceal the person, the work being often done, of course, under stress of immediate danger. A group of such defences existed, a few years ago, near Little Falls in central Minnesota, at a point where a handful of Odjibwas had once waited attack from a hostile party of their hereditary enemies, the Dakotas or Sioux. These pits were long, shallow depressions, much like sunken graves in size and appearance. The modern Algonkin, Black Hawk, had recourse to a similar expedient in a similar emergency, occurring in 1815, when he and his few braves, retreating to a natural sink-hole, dug pits in the sides of the bank with their knives, in order to protect themselves from the fire of the whites.

The Odjibwas, however, do not like fighting upon an exposed plain necessitating such devices, but prefer the protection of forest growths, giving play to their tribal dexterity in woodcraft. They have a maxim that the Sioux conquer upon prairie lands, and the Odjibwas among trees. Mr. Daniel Gookin relates in 1677 that the New England Algonkins of his time ambushed in swamps, and that certain of them, appareled from the

waist upwards with green boughs, were so disguised "that our Englishmen could not readily discern them, or distinguish them from the natural bushes."

Besides serving as ambuscades and coverts for fighting men, such excavations were occasionally scooped out as a refuge for women and children. We have an instance in point in notes of a Sioux-Odjibwa feud, kindly furnished the writer by Mrs. Elizabeth Ayer of Minnesota, a venerable lady who lived more than twenty years among the wild Odjibwas of the northwest as missionary, and who had a much longer connection with the tribe as teacher and counsellor. A party of Odjibwas, returning from a council held in 1841, at Fort Snelling, perceived in the distance a mounted detachment of Sioux warriors crossing the plains toward their encampment, and foresaw that they were to be attacked. The Odjibwas occupied a position in the midst of a wide plain, where there was neither rock, nor tree, nor shrub for shelter, and where the conformation of the surface afforded no protection. The women of this little party were immeasurably distressed because of their exposure. In pursuance of tribal custom, each began to dig in the soil a hole in which to conceal her person, using for the purpose her hands, or a knife, or whatever else fell in her way. Before they could effect their design, however, they were attacked by the foe and a bloody battle ensued.

Mr. William Warren gives a curious account of a like use of war-pits, handed down to him by a chief of Sandy Lake, the party concerned being a remnant, afterward incorporated with his own, of a people called the Mun-du-as. The direct descendants of this tribe were pointed out to Mr. Warren, and were of the Marten totem. After fearful reverses, "the people fled into the forest," says the historian, "where they buried their women and children in the ground, leaving them but a breathing-hole. The men then returned and beguiled the pursuers, by leading them in a different direction. A few escaped who afterward returned and dug up their women and children."

Cannibal Practices.

The Odjibwas believe that now and then an individual of the tribe acquires an appetite for human flesh, and becomes a confirmed man-eater. They assert that the cannibal not only feasts upon the bodies of the dead, but sometimes gratifies his palate at the expense of human life. The mass of the people, however, utterly abhor the practice, and look upon those suspected of it as monsters of depravity. A very aged and decrepit member of the Red Lake band, known by the Indians as Old Fret, was considered to be guilty of this atrocity and was held in extreme odium and superstitious dread in consequence. The man had a disorder of the respiratory organs which caused a sort of roaring sound when he breathed hard, or spoke. This phenomenon the natives attributed to the voices of the people whom he had eaten, speaking from his stomach. The Indians did not willingly remain in his presence, but were careful to offer him no affront,

and to accede with alacrity to all his little claims upon their attention. Even May-zhuck-*ke*-osh was accustomed to withdraw with marked trepidation whenever the infirm Old Fret presented himself. Historians find a modicum of fact in the belief thus illustrated; inasmuch as individual renegade Odjibwas have been convicted of cannibalism within historic times, yet it remains true that the natives in general repudiate it as an abomination.

There is a single exception to the above statement, which is based in the Odjibwa creed that it makes one brave to partake of the flesh and blood of a warrior. Probably the eastern Algonkins held to the same faith. It is related in Drake's notes to Gookin that a certain New England Indian, sentenced to death, was repeatedly let down from the branch of a tree and drawn up again, when one of his dusky friends plunged a knife to his heart, and drank his blood, remarking: "Me stronger as I was before! Me strong as me and he too!"

Mrs. Elizabeth Ayer states that the Po-*keg*-a-ma band of Indians, with whom she was stationed in 1841, made a feast during this time, in celebration of their triumph over an attacking party of Sioux warriors, and in the course of their banquet regaled themselves with Sioux flesh, boiled with their favorite food, wild rice.[2] Mrs. Ayer asserts positively that this is the only instance of Odjibwa cannibalism ever coming to her personal knowledge. Mr. Lyman Ayer, born and reared in the tribe, observed that when the Odjibwas abandoned themselves to such orgies, they proceeded with the distinct intention of promoting their own prowess thereby. The bony debris of such a repast, discovered among the remains of a prehistoric people, could readily lead to false inferences concerning its status of savagery, the result of an exception appearing like evidence of a common practice. A similar misconception might likewise originate in the aboriginal custom of dismembering the dead body of a foe, and distributing the fragments to be devoured, and the bones gnawed, by animals. The Pokegemas, for instance, hewed in pieces two Sioux warriors, killed in an attack upon their band, and delivered a portion to each family who had lost a member by the opposing tribe. In this ghastly distribution, those most recently bereaved had the preference. The mother and the bride of a certain young man received each an arm. Others were given a leg, etc. To a mother whose young daughter had just been decapitated before her eyes, a Sioux head was apportioned, which, frenzied with grief and rage, she buffetted, and spurned about the sands till exhausted, and then abandoned to the village dogs.[3]

[2] See *Some Odjibwa and Dakota practices*.—Science, Vol. VII, No. 175.

[3] Recent movements among the lake Odjibwas, such as the attempted consolidation of particular bands upon White Earth reservation, have doubtless modified certain conditions mentioned in this paper.

ABORIGINAL DWELLING-SITES IN THE CHAMPLAIN VALLEY. By Dr. D. S. KELLOGG, Plattsburgh, N. Y.

[ABSTRACT.]

PREVIOUSLY to 1878, historians of the Champlain Valley were quite unanimous in saying there were few or no aboriginal remains in northeastern New York, in the vicinity of Lake Champlain. It was generally supposed that that region was the scene of much fighting between the peoples north and south, but never permanently inhabited. Accidentally, in 1878, my attention was called to some fragments of Indian pottery found in the town of Plattsburgh. I began to investigate, and found that, not only where these fragments were discovered was there a former village site, but also was able to locate, during the four or five following years, twenty-one other dwelling-sites in the Champlain Valley, from Isle Aux Noix in the river Richelieu to Ticonderoga on Lake Champlain. I know of several others on the Vermont side of the lake, and have reason to believe there are yet others undiscovered. Aboriginal remains in large quantities scattered over circumscribed areas I have considered as evidence of a dwelling-site. No earthworks, no mounds, and, with one or two exceptions, no graves have yet been found in this whole region.

The remains consist of stone weapons, implements and ornaments; of implements of copper; of implements of bone; of fireplaces and of pottery.

The stone relics are the usual chipped, smoothed or polished varieties found in the eastern part of the United States and in Canada, and up to the present time have amounted to upwards of 20,000 in number. Yet there are some notable exceptions to the usual varieties. For instance, grooved axes and nicely grooved hammers, pestles and ornaments are rare. The material of which the chipped implements were made is found throughout the whole region. The so-called flint is abundant in the limestone of the locality. On Butler's Island in Lake Champlain, detached pieces of the dark and striated flint, a foot or more in diameter, are so driven against each other by the action of the waves that their surfaces resemble the roughened surfaces of ordinary flint hammers.

Of copper spear heads, hatchets and gouges, about two dozen have been found. These have been entirely surface, field finds. Not a single copper relic has, as yet, been obtained from a dwelling-site. Bone awls, punches and harpoons are found only in connection with broken animal bones and other remains in some of the fireplaces. Pottery, entirely in fragments, occurs in great abundance. In fact, I should hardly claim a place to be a village-site, unless a considerable amount of pottery were found in it. The rims of numerous jars have been obtained almost entire, and several jars have been nearly completely restored. Pipes, both of pottery and of stone, plain, ornamented, and sometimes representing the head of a bird or of some animal, are not very rare.

The largest village-site is the one above referred to in the town of Plattsburgh. A sand ridge, a mile long and from twenty to forty rods in

width, lying between a sluggish creek abounding in fish, and the shore of Cumberland Bay, a large bay of lake Champlain, was in prehistoric times the site of a large village. During the last thirty years the trees have been cut from this ridge and the wind has excavated through its whole width. In these wind excavations and by digging from the indications thus exposed, the relics are obtained. While large numbers of stone weapons and implements have been found at this site, such as arrows and spears, beads, knives, celts, scrapers, hammers, whetstones and so on, yet two kinds of fireplaces and the pottery are perhaps more interesting than all the other things.

One kind of fireplace is a regular kitchen-midden, containing broken bones of mammals, bones of fishes and birds, stone implements, fragments of pottery, stones that have been heated by fire, clam shells, and much other refuse material. The other kind of fireplace is merely a cluster of cobble stones that have been heated by fire. A single cluster contains, perhaps, a bushel of small cobble-stones, frequently broken into pieces. These clusters contain no implements, no broken bones and no remains of any kind whatever, unless we except some small amount of charcoal. They are quite numerous, and a wind excavation a dozen rods in width may contain as many as thirty.

The pottery in this site, all in fragments, is very abundant; portions of the rims of more than eight hundred *different* vessels having already been secured here. Almost every fragment is ornamented, generally with indentations, lines or wavy stamps. On the restored jars and on the larger fragments, are several different kinds of ornamentation, always elaborate and gracefully arranged. Some of the vessels have many hundreds of indentations and others several thousands. The ornamentation generally extends from the edge of the rim on the outside to the bottom, though some of the bottoms, not one of which is flat, are the only parts that are perfectly plain. The very edges of the rims are often indented and some of them are handsomely scalloped. Frequently the ornamentation extends from the rim, one, two or three inches down on the internal surface of the jar. The main portion of the inside surface is, however, covered with irregular lines which seem to have been made by a rough smoother. The rims themselves are generally circular, though some of them are oval. The restored jars hold from three to eight quarts each.

The clay of which the vessels are made was not mixed with sand, but contained angular quartz crystals, some mica and probably feldspar. I have not found pounded shell mixed with it. No paint nor other coloring matter seems to have been used, yet some of the vessels are blackened by smoke. Carbonized material clings to the inner surface of some of the fragments, showing that the careless cook let the dinner burn on. On the inner surface of some of the pottery are occasionally seen the fine lines made by the skin of the palmar part of a human thumb or index finger. I have a considerable portion of one jar whose fragments are an inch or more in width and several inches in length. The upper edge of each of these pieces is convex, longitudinally, and the under edge is concave.

When replaced in their original position a convexity fits into a concavity above, showing that this jar, at least, was made piece by piece from below upwards. This vessel was ornamented by a small wavy stamp that left an impression not unlike a bird flying. I have not yet found a representation of any portion of the human body, or of an animal, on any of the jars.

ABORIGINAL NEW YORK VILLAGES. By Rev. W. M. BEAUCHAMP, Baldwinsville, N. Y.

[ABSTRACT.]

SOME of the finest New York relics were not found on enclosed sites, but belonged to early travellers or residents. Open sites differed more than the fortified, yet some of both may have been contemporaneous. Early earthworks in New York are rarely rectangular, but stockades are often of this form. Earthworks probably supported palisades, but were replaced by cross timbers at a later day. When the Indians got new ideas and tools from the whites, forts soon changed. Village sites were often abandoned, but not at intervals of ten years, as stated by the French. These changes must be considered in dealing with age and population, as successive sites often occur in groups. Digging necessary trenches was less laborious than supposed, and for a palisade a continuous trench was made, not separate holes. Stockades may have had as many gates as earthworks, but they have often escaped attention.

The long house was not peculiar to the Iroquois, nor prominent among them, and Greenhalgh noticed it only in one town. Morgan's estimate would give this town alone five times the whole Seneca population. Greenhalgh's account allowed two or three warriors to a lodge throughout the Five Nations. The forts were so long and narrow as often to afford little room for long houses, and the houses were in the narrowest part. One fort, over 600 feet long, is but little over 100 feet wide for nearly half its length. Lodges were built of bark, bore the totem of the owner at one end and were often adorned with coarse figures in relief. A round form was sometimes used.

Sir Wm. Johnson said that every nation, tribe and family had its own allotment of land, and early writers refer to a personal title to cultivated fields.

Burial customs varied, according to changing fashions, and contemporaneous nations differed in these. Both the sitting posture and the horizontal were frequent. Mound burial was occasional and local, and articles were not always placed in graves. Broken articles in towns may not have been the result of warlike violence. More commonly they result from the excesses of the Dream Feast and other festivals.

RELICS OF AN "INDIAN HUNTING GROUND." By A. WANNER, York, Pa.

[ABSTRACT.]

THIS "Indian Hunting Ground" extends along the Codorus creek, having a breadth of two miles and a length of six, with the city of York, York Co, Pa., in its centre. It is a region assumed to have been only occasionally visited by the Indians and reputed to be barren of relics. In a recently published "History of York County," it is said that "the original settlers here found immense tracts of land entirely denuded of timber by the annual fires kindled by the Indians for the purpose of improving their hunting grounds."

In order to ascertain just what evidences of Indian occupation could yet be found strewn over the fields—many of which have been cultivated for more than a hundred years—careful search was made. That the search was well rewarded is proven by the number and variety of specimens collected. The classification of Indian implements given in Doctor Abbott's "Stone Age of New Jersey" was closely followed in describing the specimens obtained, all of which were collected within the last five years. The collection includes samples of lanceheads, spearheads, arrowheads, knives, celts, drilling stones, axes, hatchets, pestles, soapstone dishes, pottery, hammers, gorgets, stone chips and implements of unknown uses.

The axes found, as a rule, are small, with a groove extending the whole way around the stone. Most of those that come from the Susquehanna, near the mouth of the Codorus, where numbers are found, have one ungrooved side; fully three out of every four are thus fashioned. Now, why should the predominating type of a region, distant only about ten miles and within easy access, be unrepresented here by even so much as a single specimen? The most plausible inference is that the two types were intended for different purposes. One of the axes exhibited, weighing only one pound, has two parallel grooves. Several were picked up in the public road where they had been thrown into the mud holes along with other stones from the field.

The fragments of pottery shown, made out of clay and broken pebbles, are similar to pieces from the Susquehanna. The impressions are evidently of two kinds, those made by a point of some sort in the hands of the ancient potter, and those which resulted from the structural irregularities of some receptacle within which the plastic clay was first shaped.

Among the "implements of unknown uses" deserving special mention, is a triangular prism of slate about five inches long and having two holes that meet at the ends. Two of its sides bear symmetrical scratches, now in part defaced by the wear and in part by the ancient use of the stone for whetting purposes.

Flakes of felsitic rock, of jasper, and of agate are found distributed over nearly all the fields along the Codorus and its tributary runs. They were undoubtedly chipped near where they now lie. Their presence proves that implements were here wrought out of the rough stone into desirable shapes.

None of these minerals are found *in situ* in this locality. Fully twenty miles distant, in the South mountain, the felsitic rock occurs. Where the jasper and agate were brought from has not been determined. The other specimens found do not deserve special mention.

In conclusion, attention is called to a few difficulties that beset the careful searcher. Fields that now yield few relics may have them deeper down. The building of dams has materially changed our streams. Places that once were high and dry on the bank are now covered by every freshet. As a consequence, the sediment has accumulated, and the relics have been buried beyond the reach of the plough. Occasionally, a field is washed bare of all the loose soil. In that event you cannot reasonably conclude that the number and quantity of specimens found there indicate a more dense settlement than elsewhere. Taking these and other circumstances into consideration, in connection with the relics found, the author believes that this region was much oftener frequented and longer occupied by larger bands of Indians than the historian leads us to infer. This place may have been the site of a well-established settlement; a settlement in which much the same primitive occupations were engaged in, as characterized well-known and more extensive settlements along the Susquehanna. If this region is an average sample of the supposed barren lands, may we not conclude that America was more thickly settled, or longer inhabited, perhaps both, by the Indian, than is generally supposed?

WHAT IS IT? By Prof. E. W. CLAYPOLE, Akron, Ohio.

[ABSTRACT.]

IN this paper an account was given of some curious apparent casts which have for some years been puzzling objects in the cabinet of the Davenport Academy of Science and of others. They have at first sight the appearance of casts of some species of Cardium. But little examination is required to show that this is not their true nature. By some they have been considered frauds. The evidence is reviewed at length and the theory of fraud shown to be untenable. It is also shown that they are not Niagara fossils and not fossils at all. A summary of the facts points rather to the conclusion that they must be looked on as relics of antiquity, made either by the ancient inhabitants of the country or for the purpose of trade with the Indians in very early days.

SENSORY TYPES OF MEMORY AND APPERCEPTION. By Dr. JOSEPH JASTROW, Philadelphia, Pa.

THE characteristic here treated is the role in the mental life of the individual played by the information gained from the several senses, particularly from sight, hearing and the tactual-motor sensations. There are

persons who assimilate their mental food mainly through visual impressions, others mainly by auditory, and a third mainly by motor, while to a fourth and doubtless a large group all the avenues of sense are equally open.

The visual type is the most common and has been best described. Mr. Galton's studies on the visualizing power indicate the wide divergence in various persons in the power to picture an experience vividly. Instances of persons possessing the gift to an unusual extent are not uncommon; to this class belong the chess-players who play several games at once when blindfolded. Sight is the sense most active in dreams as well as in the hallucinations of the deranged. Abnormal associations, such as a sound calling up a color and the like, are more frequently in terms of it than of any other sense. There are persons who interpret much of their knowledge by sound; extreme instances of this are seen in such as Beethoven composing symphonies after his deafness, while in dreams, hallucinations and odd associations hearing is second only to sight. Instances of motor-mindedness, are less common, though in the mental make-up of many it forms an important role; to Laura Bridgman it is almost the sole avenue of knowledge.

That these divisions of the memory are not arbitrary, but correspond to real physiological differences in the brain centres, is shown by pathological evidence. Cases are cited in which the visual or (in part) the auditory, or the motor memory and apperception pass away separately leaving the others intact.

The practical educational import of these facts is apparent. The eye-minded man will waste energy by attempting to learn by ear, and as these traits are manifest in childhood much time is doubtless wasted in absence of this knowledge. Dr. J. Mortimer Granville lays stress on this information in his "Secret of a Good Memory." He there gives a test for discovering whether one is eye-minded or ear-minded, which is good but inadequate. I have tried further tests (fully described in the paper) and depending on three principles. (1) Find the limit of capacity for taking in a series of simple visual and of auditory impressions, disconnected and connected words after a single hearing or reading. The larger limit shows the stronger sense. (2) To experiment with sentences, etc., beyond this limit and observe the amount as well as the nature of the error committed. One may also count the number of repetitions necessary to fix long passages, etc. (3) Have both processes going on at once and see which one usurps most of the attention and is least interfered with. The eye-minded will know more of what he reads than what is simultaneously read to him, while with the ear-minded the reverse is the case. In all the experiments a longer or shorter interval before the repetition may be inserted and the strength of memory as well as of apprehension be tested. Hints for testing the importance of the motor element are also given. Besides these formal tests each one will find many evidences of his bent in the doings of every-day life.

THE STUDY OF A SMALL AND ISOLATED COMMUNITY IN THE BAHAMA ISLANDS. By Prof. T. WESLEY MILLS, McGill University, Montreal, Canada.

[ABSTRACT.]

THE writer's views are founded upon a personal study of this community during a residence of some weeks on Green Turtle Key, a small island of the Bahama group opposite Abaco. The population is made up of blacks and whites in nearly equal numbers and amounts in all to about six hundred. The blacks are the descendants of former resident slaves. The chief sources of subsistence are pine-apple culture and the sponge fishery. The population as a whole is poverty-stricken. The food used generally is physiologically insufficient. Neither meat (nor fish), milk nor eggs, can be reckoned in the dietary of the many. The blacks, moreover, by their manner of closing up their houses during the night, considering the large numbers occupying one dwelling in proportion to the cubic space, are compelled to breathe a vitiated atmosphere during almost half the time. Hence, though the climate is favorable, pulmonary consumption is not unknown.

There is little social intercourse, except for purposes of business, especially among the whites.

For a large portion of the year ships scarcely visit the island; so that, all things considered, there is thus an environment of the most monotonous kind. The wrecker's spirit and the gambling spirit generally survive. A study of the temperature taken four times daily by the writer, as well as the records of others for the year, shows that a temperature uniformly high prevails continually. To this great importance is to be attached in explaining the want of energy and enterprise manifest on every hand among these people. The whole environment is much less suited to the Anglo-Saxon than to the Negro race. The whites show a type-degeneracy to be attributed to lack of food, insufficient mental stimulus and especially to the uniformly high temperature. The fact that there are few immigrants and the smallness of the total white population give very limited play to "sexual selection."

The causes of the physical and psychical degeneracy to be observed on Green Turtle Key, in the Bahama Islands, may be thus summarized: an inadequate diet in the physiological sense, combined with impure air; the depressing effect, physical and psychical, of a uniformly high temperature; the influence of uncertainty in the reward of exertion, and of unfounded expectation, begetting the gambling spirit; the limited play of sexual selection; and the lack of variety in the afferent influences reaching the nervous centres (experience); all of which can be studied especially well in this community on account of its diversity in race composition and its comparatively isolated and stable condition.

THE TRUE BASIS OF ETHNOLOGY. By HORATIO HALE, Clinton, Ontario, Canada.

[ABSTRACT.]

ETHNOLOGY has been defined as "the science of the races of men." Some eminent scholars have doubted whether there can properly be said to be such a science, inasmuch as all attempts to classify mankind into groups have thus far failed. There is no agreement among ethnologists as to the number of distinct races, or as to the criteria by which they are to be distinguished. The color of the skin, the texture of the hair, the shape of the skull, and other physical traits have all been found insufficient. Language, which has been proposed by some writers, has been rejected by others as a means of distinction, on account of difficulties arising partly from misconceptions as to the nature and value of linguistic stocks, and partly from the mixture of races. The object of the paper is to show that these difficulties, when properly regarded, form no real objection, and that linguistic stocks are in ethnology what the physical elements are in chemistry, the true basis of the science. The classification of races by languages is the only classification which has a genuine scientific value. The results are definite and certain, and lead to conclusions of great practical importance. Illustrations are given from the history of various races, including the African and American tribes, the Iberians, and the Indo-European nations.

THE SUBDIVISIONS OF THE PALÆOLITHIC PERIOD. By Dr. DANIEL G. BRINTON, Media, Penn.

[ABSTRACT.]

THE Stone Age has been subdivided into the Palæolithic and Neolithic periods dependent upon certain peculiarities in the manufacture of the implements themselves; but the subdivisions of these periods have been upon other characteristics. The writer proposes the subdivision of the palæolithic period into (1) the epoch of simple implements and (2) the epoch of compound implements, upon the same bases as the main subdivisions.

THE SERPENT MOUND OF ADAMS COUNTY, OHIO, AND ITS PRESERVATION BY THE PEABODY MUSEUM OF AMERICAN ARCHÆOLOGY AND ETHNOLOGY. By Prof. F. W. PUTNAM, Cambridge, Mass.

[ABSTRACT.]

A BRIEF description was given of the singular earthwork in Ohio, now so generally known as the Serpent Mound, and its surroundings, for the purpose of calling attention to the important fact that this interesting

monument of antiquity was now preserved from destruction, a fate that would soon have followed had it been left unprotected.

About sixty acres of land have been secured on the eastern side of Brush Creek, including the high ridge upon which the long earthwork in the shape of a serpent, with the oval work in front of the serpent's mouth, is situated, the conical mound southeast of the serpent, and the land about, upon which are indications of a village-site and a burial-place.

In the southeastern corner of this lot of land there is a beautiful grove of maples shading two springs, one of which is a "sulphur" spring, and here it is proposed to build a spring-house of stone, and prepare a picnic ground. A road is to be laid out, leading from the Locust Grove pike[1] to this picnic ground, and shaded paths will lead from the grove to the conical mound and to the serpent.

Several years since these earthworks were ploughed over and cultivated for a few years, and holes were dug by seekers for buried treasures; paths and washouts have also injured the embankment, but all these injuries will be repaired, and the earth ploughed from the top of the embankment down its sides will be replaced, but without attempting to restore the banks to their original height, and the banks will be covered with grass. In this manner the work will be preserved for the benefit of future generations, and the "Serpent Mound Park," with its many interesting features and its beautiful surroundings, will be opened to all comers for enjoyment and for the study of a monument which is both unique and instructive in American archæology.

For the accomplishment of these important results, archæologists for all time to come will be indebted to the energetic action of a few ladies in Boston, whose hearty coöperation in the efforts to save a monument which a recent visit had convinced me was doomed to immediate destruction unless at once preserved, secured the necessary funds by subscription. With this money the land was purchased and accepted as a trust by the Trustees of the Peabody Museum, a department of Harvard University. Over five thousand dollars were raised by the ladies, of which about four thousand were expended for the land and incidental expenses. The remaining sum will be used in repairing the mound and fencing it in, and, as far as possible, in building the roads and spring-house. In order to carry out all the proper arrangements in the park and make it what it should be, and properly protect it by fences, fifteen hundred to two thousand dollars more are required. As this is, in every sense, a National Park in which every American should take an interest, it is to be hoped that the efforts of the ladies of Boston will be seconded by friends in other places, and this small sum soon be secured. The example thus set must bear good fruit, and we can now feel sure that a greater interest than ever before will be taken in the preservation of the ancient monuments of America.

[1] The nearest point by railroad are Peebles and Hillsborough.

ON THE PRESERVATION OF ARCHÆOLOGIC MONUMENTS. By ALICE C. FLETCHER, Peabody Museum, Cambridge, Mass.

[A letter addressed to the Section.]

THE importance of preserving the remains of the ancient peoples of America needs no argument before this Section. Students are already doing their part toward saving the past history of the American races; but there is a task to be accomplished which it seems fitting to ask Congress to take up in behalf of our national culture. This is, to set aside certain portions of the public domain in the southwest territories in which are characteristic remains of former and of present aboriginal life, and holding them as national reserves.

Many of the most remarkable ruins and dwellings are upon land of little value to the settler, so that the claims of archæology do not interfere with local prosperity.

Each year of study and research makes it important to hold these monuments of a past and fast fading life, for the benefit of the future, and they are daily in more and more danger from the curiosity and zeal of traders. If they are not speedily preserved many will irrevocably be lost.

I would therefore propose that the Section take such action as is deemed best to memorialize Congress, and secure the needed legislation, to effect such preservation as shall stand as a monument of our interest as Americans in the history of our country.

[This communication called forth many remarks upon the importance of preserving the archæological monuments of America, and the Section nominated Miss Alice C. Fletcher and Mrs. T. Stevenson as a committee to memorialize Congress to pass laws for the preservation of such of the archæologic monuments on the public lands as may be determined as most important. The Council of the Association confirmed the nominations by the Section and the Committee were appointed.— EDITOR.]

RECENT ARCHÆOLOGICAL INVESTIGATIONS IN THE CHAMPLAIN VALLEY. By Prof. G. H. PERKINS, Burlington, Vt.

ANTHROPOLOGY AS A STUDY IN A COLLEGE COURSE. By Prof. G. H. PERKINS, Burlington, Vt.

ON THE ASSUMED MYTHICAL CHARACTER OF PROFESSOR HEER'S ATLANTIS THEORY. By Prof. JOHN KOST, State Geologist of Florida, Tallahassee, Florida.

On the correlation of certain mental and bodily conditions in man. By Dr. Chas. Porter Hart, Wyoming, Ohio.

China in America: a study of the social life of the Chinese in the eastern cities of the United States. By Stewart Culin, Philadelphia, Pa.

System of symbols adapted for American prehistoric archæology. By Dr. Wills De Hass, Washington, D.C.

History and present condition of prehistoric archæology in Western Europe. By Thomas Wilson, Washington, D.C.

[An abstract of this paper is published in the American Antiquarian.]

Exhibition and description of a large votive adze made of jadeite, from Oaxaca, Mexico. By George F. Kunz, New York, N. Y.

[This paper will be printed with a colored plate of full size, in the Report of the Bureau of Ethnology, Smithsonian Institution.]

On a remarkable carving in rock crystal, representing a human skull. By Geo. F. Kunz, New York, N. Y.

[This paper will be printed in the American Antiquarian.]

Music and poetry of the Eskimos. By Dr. Franz Boas, New York, N Y.

The Indians of British Columbia. By Dr. Franz Boas, New York, N. Y.

The Niam Niams and their neighbors. By Dr. Franz Boas, New York, N. Y.

The palæolithic age in America. By Rev. S. D. Peet, Mendon, Ill.

Totamism and animal worship: was it confined to races who were in the hunter stage? By Rev. S. D. Peet, Mendon, Ill.

Some of the unsolved problems connected with the stone age, especially as to its subdivisions. By Rev. S. D. Peet, Mendon, Ill.

THE SANTHALS OF NORTHEASTERN BENGAL. By Dr. S. KNEELAND, Boston, Mass.

[This paper will be printed in full, with illustrations, in the Bulletin of the Essex Institute.]

EVIDENCES OF A PRE-INDIAN OCCUPATION OF NEW JERSEY. By Dr. C. C. ABBOTT, Trenton, N. J.

THE RELATION OF ARCHÆOLOGICAL REMAINS TO RIVER TERRACES. By A. W. BUTLER, Brookville, Ind.

PRELIMINARY STUDIES OF PLATYCNEMIC TIBIÆ. By Dr. FRANK BAKER, Washington, D. C.

THE PHILOSOPHY OF WIT, HUMOR AND SATIRE. By MELVILLE D. LANDON, New York, N. Y.

SECTION I.

ECONOMIC SCIENCE AND STATISTICS.

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ADDRESS

BY

HENRY E. ALVORD,

VICE PRESIDENT, SECTION I.

ECONOMY IN MANAGEMENT OF THE SOIL.

At the great Boston meeting, in 1880, amendments to the constitution of the American Association were proposed, effecting an entire re-organization and including the formation of the Section of Economic Science and Statistics. The amendments were adopted the next year at Cincinnati, and went in operation at the Montreal meeting, in 1882. This section was then organized and held its first session for the consideration of papers referred to it.

There have been, consequently, five meetings of this section of economic science and statistics, prior to the present. This hardly furnishes age or material for a history, but I venture, in discharge of the duty assigned me to open the sessions of this year, briefly to review the work of the past, as illustrating the purposes and scope of this section of the Association and suggesting some of the subjects to which it may profitably give attention in the future.

In his opening address for the Montreal meeting, Dr. E. B. Elliott of Washington, the first presiding officer, and ever since conspicuously identified with this section, made statements regarding its origin and objects which may well be repeated.[1]

The American Association was largely modelled after the British Association for the Advancement of Science. That body was organized in 1831, and in the twenty-fifth year of its existence established a section of economic science and statistics. The similar section of the American Association was organized at its thirty-first annual meeting.

[1] Vol. XXXII, A. A. A. S., p. 445.

"The subjects which properly pertain to this section are scientific, not speculative. The section is to deal with facts, known facts; not scattered, heterogeneous, unrelated facts, but known facts reduced to order."

The scope of the section permits "the consideration of a vast extent of special subjects relating to man, his nature, possessions and his surroundings of all kinds, including facts tending to show the condition and changing condition, of communities, races, individuals and interests."

But under its entire title, "the subjects to be submitted to this section are not exclusively those which belong to economic science, but may pertain to any facts to which the application of statistical methods is peculiarly adapted to facts susceptible of numerical expression and which may be arranged in tables."[2] To this should be added, all facts which may be advantageously presented, compared or contrasted, by graphical methods of illustration.

As in the British Association a section of statistics only existed for years before economics were added to its scope, so in this section the statistical features took the lead. At the Montreal meeting nine or ten of the fifteen papers considered were of a statistical character, and the next year, at Minneapolis, the late Dr. Franklin B. Hough, as vice president, opened the session with an elaborate technical address on *The Methods of Statistics*.[3] But the ten papers following nearly all presented economic questions and this has been the character of much the greater number of subjects since considered by the section. (It is only fair to add, in this connection, that our good friend, Doctor Elliott, was not present at Minneapolis).

The largest and most important meeting of this section was at Philadelphia, in 1884. The sessions were opened by Gen. John Eaton, jr., as vice president, with an address upon *Scientific Methods and Scientific Knowledge in Common Affairs*.[4] Unfortunately, this was not preserved in full, although the section secretary secured an excellent abstract. General Eaton emphasized a characteristic feature of this section: while the papers considered are treated in a scientific manner, they are generally upon subjects having a lively public interest and are presented in a popular form.

[2] These quotations from pp. 446–7, Vol. XXXII, A. A. A. S.
[3] Vol. XXXII, do., p. 431. [4] Vol. XXXIII, do., p. 621.

Several of the distinguished foreigners present at Philadelphia contributed to the sessions of Section I, and thirty-one papers were considered, being more than one-tenth of all accepted that year by the Association.

At the Ann Arbor meeting, this section received fourteen papers, and ten last year at Buffalo. In all, therefore, Section I has had read and discussed, at its five yearly meetings, eighty papers, of which four-fifths were upon economic subjects, the rest being purely statistical.

The annual address of 1885, by vice president Edward Atkinson was upon *The Application of Science to the Production and Consumption of Food*,[5] and last year Dr. Joseph Cummings spoke of *Capitalists and Laborers*.[6] The appropriateness of all these vice-presidential addresses will be noted, and timely suggestions might be obtained by reviewing them. It should be remarked in passing, that the address of Dr. W. J. Beal, before the section of biology, in 1883, upon *The Needs and Opportunities of Agriculture*,[7] and that of Dr. H. W. Wiley, before the chemical section. in 1886, upon *The Economical Aspects of Agricultural Chemistry*,[8] would both have been peculiarly suited to the consideration of *this* section.

The sixteen statistical papers read before the section may be grouped about equally under these heads: Census; Financial; Measures, including Time; and Sundries.

The sixty-four papers upon economic subjects admit of this classification, in numerical order: Educational; The Food Question, including Food Fishes; Forestry; other agricultural topics; Financial; and the Indian as an Economic Problem. This leaves twenty-eight papers so diverse as to be unclassified.

As examples of work in the past, especially appropriate to the sphere of this section, the titles of several papers are quoted:

Educational:

The Appprenticeship Question and Industrial Schools.[9]
The Aims and Methods of Manual Training Schools.[10]
Proposed "New Departure" in the Form of Deaf-mute Schools.[11]

On Foods:

Percentages and Cost of Nutrients in Foods.[12]

[5] Vol. XXXIV, A. A. A. S., p. 425. [6] Vol. XXXV, do., p. 339. [7] Vol. XXXII, do., p. 279.
[8] Vol. XXXV, do., p. 125. [9] Vol. XXXIII, p. do., 651.
[10] *Ibid*. p. 675. [11] *Ibid*. p. 652. [12] *Ibid*. p. 648.

Relative Values of Human Foods.[13]
Possibilities of Domestic Sugar Supply from Sorghum.[14]
Food Fishes:
The German Carp in the United States.[15]
Oyster-Farming in Connecticut.[16]
Results Produced by the Artificial Propagation of Fish.[17]
Forestry:
Some of the Economic and Scientific Principles in Tree-growth and Tree-destruction.[18]
Investment in Forest Culture Compared with other Productive Industries.[19]
The Structure and Economic Value of some of our Woods.[20]
Among those unclassified:
Some Economic and Social Effects of Machinery.[21]
The Philosophy of Criminal Development.[22]
Centenarianism in the United States.[23]

These fairly illustrate the scope of Section I, and suggest the character of topics, which, presented in proper form, and within reasonable limits, will, I feel sure, be welcomed hereafter, as suitable contributions to the proceedings of this branch of the Association.

The very breadth accorded to this section has caused its limits to become somewhat indefinite, and it must be admitted that there has been a tendency to refer to "I," papers which were inappropriate or distasteful elsewhere, and, apparently, without other reason, they have been taken in here, through a commendably philanthropic sympathy for the homeless and wandering. Reciprocity has sometimes resulted, the section being "taken in" by them! For example, "Investigations upon the power to move railroad trains and mechanical inspection of railroad tracks,[24] certainly belonged to Section "D," where it doubtless deserved a place; and "A new method of land cultivation by the use of dynamite,"[25] was a paper of the kind which may be properly declined as purely chimerical. It certainly behooves our sectional committee to scrutinize offerings and maintain a proper standard. The limitations defined by the first presiding officer of the section are well expressed and should be enforced: "The subjects considered must

[13] A. A. A. S., Vol. XXXIV, p. 504. [14] *Ibid.* Vol. XXXV, p. 363.
[15] *Ibid.* Vol. XXXII, p. 458. [16] *Ibid.* p. 460. [17] *Ibid.* Vol. XXXIII, p. 647.
[18] *Ibid.* Vol. XXXI, p. 612. [19] *Ibid.* p. 612. [20] *Ibid.* Vol. XXXIII, p. 647.
[21] *Ibid.* p. 638. [22] *Ibid.* p. 675. [23] *Ibid.* Vol. XXXV, p. 360.
[24] *Ibid.* Vol. XXXIII, p. 675. [25] *Ibid.* p. 673.

be truly scientific, that is, knowledge reduced to order, pertaining to the interests of man, either singly, as an individual, or associated in communities, or related by some common law.[26]

In reviewing the work of the section as a whole, one cannot fail to note that while purely statistical matters, questions of public policy and topics fairly belonging to social science, have received a due share of time and attention, the tendency has been towards increasing consideration of the many economic problems connected with the material wants of man. This is certainly justifiable.

In this great metropolis or wherever our Association meets, we are shown with pride the abounding evidences of the progress of a great nation and the material prosperity of its people. Tracing this visible wealth to its source, we find that it has all, with insignificant exceptions, been produced from the soil.

The American inheritance was a fertile soil, and to the generous stores of three elements of plant food, potassium, phosphorus and nitrogen, the accumulations of ages, we owe all that we have and have had, of things material. A policy perhaps warranted by the circumstances, but none the less improvident, has marked the growth of the nation. Generation after generation has recklessly drawn upon the stored fertility of the land, with no systematic effort at restitution, not only to supply the current support of the people, but the surplus which has provided all our apparent wealth other than land, and enabled us to make all our public and private improvements.

The relation of this accumulated wealth to the annual cost of maintenance was strikingly shown by Mr. Atkinson,[27] when he stated to us at Ann Arbor, that the value of all the possessions of our people, land excepted, does not equal the sum total of three years' production of our industries. At the same time he presented the startling fact that "the average product, to each person, in this most prosperous country, measured in money at the point of final distribution for final consumption, does not exceed fifty to fifty-five cents per capita," and after we have provided for maintaining our capital and for government support, "each average person must find shelter and be supplied with food and clothing, out of what forty to forty-five cents per day will buy, because such is the measure in money of all that is produced and

[26] A. A. A. S., Vol. XXXII, p. 446. [27] *Ibid.* Vol. XXXIV, p. 442.

we cannot have more than all there is." These facts, taken together, show the very small margin upon which we are working and the great excess of the necessary cost of living over the surplus which furnishes our luxuries and accumulations. While, therefore, we profitably devote our thoughts to physical comforts, pleasures and intellectual development, to social progress and public improvement, how much more should we study the many economic problems connected with the necessaries of life, upon which we expend at least four-fifths of our annual income!

For food, clothing, shelter and fuel, we depend almost entirely, directly or indirectly, upon the soil. The rapidly increasing demands of our own country are met and more than met, so far as mere quantity is concerned, for a great surplus is annually sent abroad. For twenty years, agricultural products have constituted three-fourths of the total exports from the United States, while in single recent years this proportion has reached eighty-three per cent and amounted in value to nearly $900,000,000. And it is manifest that this superabundance of soil products will continue, despite any possible increase in population, at least well into the next century. But the wisdom and economy of our present systems of production and disposition are a very different matter. A steady draft continues upon the important elements of fertility with no adequate system of restitution or recuperation for the soil. Every crop removed from the land diminishes its store of plant food and thus reduces its productive power. The average production per acre, notwithstanding the progressive improvements in our farming, has steadily decreased, not only in the older states but in some of the newest and richest sections. The great wheat fields of the northwest and of California do not produce, at the present time, more than half the crop formerly obtained from them.[28]

We boast of our great exportation of soil products, forgetting that this really means the sending to foreign lands of great blocks of our store of natural fertility, thus disposing of the main source of our national wealth by the ton and by the million.

The steady reduction in the fertility of the soil, which results from the annual draft by cropping, and the absolute loss incident to the ordinary disposition of the crops, are much greater than

[28] H. W. Wiley, in Vol. XXXV, A. A. A. S., p. 135.

commonly understood and a matter so important as to demand serious consideration.

For present purposes it is sufficient to refer to only three elements of plant food, which are of vital importance and in which the soil is most likely to be, or to become, deficient. A computation based upon the mean agricultural products of the United States, at the present time, the average composition of these products as known to chemistry, and the cash value of the chief fertilizing materials in domestic markets, give the following stated quantities and values of the three elements named, which are taken from the land by the farming operations of every year:[29]

4.000,000 tons of nitrogen,	worth at $360.00 per ton,	$1,440,000,000.00
3,000,000 " " potash,	" " $100.00 " "	300,000,000.00
2,000,000 " " phosphoric acid,	" " $120.00 " "	240,000,000.00
Total value,		$1,980,000,000.00.

The effect upon the soil depends, of course, upon the disposition of the products embodying these enormous quantities and values. Fortunately, a very large part remains upon or is returned to the land, in the processes of harvesting and preparing for market, and more, in the form of wastes and residues incident to consumption. On the other hand, there are vast absolute losses resulting from the well-known wastes of towns and cities, besides the portions actually sent to foreign countries. To apportion exactly the disposition made of these products, and hence of the fertilizing elements represented thereby, is impossible; but, as to the latter, a rough approximation divides the total into three parts, respectively remaining on the land, returned to the soil and wholly removed from it.

This country imports the agricultural products of other countries in great quantities, but in kind far less important than our exports to the question in hand. The articles exported are largely of a character especially rich in plant food. Making due allowances, therefore, I estimate the average exportations as representing thirteen per cent of the fertility value of our total products

[29] H. W. Wiley, in Proceedings A. A. A. S., Vol. XXXV, p. 125. While the computation for the cereals and hay crop is undoubtedly correct, I cannot accept the assumed ratio in chemical composition between these and all other agricultural products as equal to their respective market values (*Ibid.* p. 134). Therefore the totals are scaled down vigorously from those given by Doctor Wiley, as, if erring, I prefer to be within the truth.

and our absolute wastes at home, at more than twenty per cent additional. Together, these constitute a full third of the figures above given; or an annual removal from American soil, of nitrogen, potash and phosphoric acid worth in the markets of this city, to-day, more than $600,000,000! By our present system or rather continued improvidence, in the production of the necessaries of life, we are thus diminishing, at this alarming rate, the original capital of our foundation industry.

When products are exported, mainly food, which are worth $700,000,000 on our shores, there is included plant food, all needed at home, which we cannot replace for one-third of that sum.[30] This fertility never comes back. It goes to enrich other lands or is washed into seas from which we do not even get the fish and the kelp. Those of us who are contending with impoverished soils are well placed to appreciate the sober subject of agricultural exhaustion and are in duty bound to send an earnest word of warning to those who labor on newer lands.

The researches of modern science have done much in establishing truths of practical value regarding the effect upon the fertility of the land, of removing different crops and products, and hence teaching us what should be consumed at home and what may be

[30] This statement seems incredible, but take wheat as a single example. From the figures given by Doctor Wiley, already referred to, and from the authorities cited by him, the following figures are obtained:

Average crop of wheat, grain, 450,000,000 bushels; straw, 22,689,000 tons.

Wheat grain; nitrogen, 1.944 %; ash, 2.06 %; (potash, 31.16 %; phosphoric acid, 46.98 %).
" straw, " 0.496 " " 5.37 " " 13.65 " " " 4.81 %).

Pounds.	Nitrogen.	Potash.	Phosphoric acid.
Wheat grain,	524,880,000	173,311,920	261,302,760
Wheat straw,	225,074.880	332,623,008	117,210,012
Total pounds,	749,954,880	505,934,928	378,512,772
Value per pound,	$.18	$.05	$.06
Values,	$134,991,878.	$25,296,746.	$22,710,706.

Total values of plant food in grain and straw, $182,999,390.
" " " marketable crop in grain and straw, $450,000,000.

Value of plant food in crops, 40 % of its market value.

The figures for production and composition of products cannot be disputed. The measures of value are arbitrary; but what others can be used? If we send the articles containing these fertilizing elements to foreign lands and then attempt to secure equivalents in fertilizers to restore to our soil, the market prices must be paid for them. These prices, as agreed upon by state chemists, are used above as the measures of value. Moreover, there can be no question that the phosphoric acid, etc., as existing in the products exported, is in a form more available for plant food, and hence worth more per unit of weight, than in the usual forms of commercial fertilizers.

profitably sold. Thus, if ton after ton of farm produce be removed from a western farm to an eastern market, or from any American farm to a European market, it makes a great difference, eventually, to the land where produced and to its owner or user, whether these tons be of corn or cotton, beef or butter.

The following table illustrates this feature in connection with some of the principal exports of the United States:[31]

Articles of export.	Mean annual exports in tons.	Approximate value of one ton at place of export.	Value of plant food in one ton.	Percentage of plant-food value on the market value.
Cotton-seed meal.	250,000	$ 26.00	$28.04	108 %
All "oil cakes" and meals.		24.00	23.80	100
Corn (maize).	14,000,000	(36 bush.) 23.00	6.94	30
Wheat.	3,000,000	(34 bush.). 34.00	8.80	26
Wheat flour.	750,000	(10 bbls.) 50.00	7.08	14
Beeves, alive.	100,000	100.00	13.98	14
Dressed beef.	50,000	160.00	13.99	8¾
Tobacco.	150,000	200.00	15.92	8
Pork products.	500,000	200.00	13.43	6¾
Cotton.	1,000,000	(4 bales) 200.00	60	0¼
Butter.	15,000	(40 tubs) 400.00	.52	0⅛

The chief lesson of this table is the great loss incurred by exporting cotton seed, cereals and breadstuffs, instead of animal products; and a double loss occurs here because, besides the matter of plant-food, is that of transportation. It requires an average of about eight tons of grain and like products to bring the price of one ton of animal products, and freight is paid on eight tons instead of one. If we must export wheat or wheat-flour, it should all be in the form of flour; for every ton of this grain, bringing $34.00, carries away $1.72 worth of plant-food more than a ton of flour, for which $50.00 is received. But this is not all; instead of the ton or thirty-four bushels of grain, we have to send

[31] The annual reports of the U. S. Bureau of Statistics, Treasury Department and of the Department of Agriculture are depended upon for the mean exports and their value. For the chemical composition, the authorities used are Wolff, Gilbert, Mc Murtrie, Jenkins, Wiley and Richardson; and the rates for nitrogen, potash and phosphoric acid are the same as quoted from Doctor Wiley and used on previous pages.

over one and a half tons, or fifty bushels, to equal a ton of flour. The wheat exported annually (three million tons) equals 2,000,000 tons of flour. Were flour sent in place of this grain, the breadstuff going abroad would be the same, and the receipts for it the same, while the plant food exported would be less in value by $12,240,000.00 per annum, and the cost of freight upon one million tons would be all, or nearly all, saved. It is also seen to be five per cent better to export dressed beef than the equal in food of live animals, and this is strictly true, because of the provisions now so general for saving all animal offal and refuse at ports of export, for agricultural purposes. The greatest contrasts, however, are between cotton seed and cotton, in one case, and grain and butter in another. Grain is worth more than one-fourth its export value as manure for home-use; and cottonseed meal is actually worth, to-day, more as a fertilizer than it sells for as stock food, while we might continue to export cotton (fibre) and butter, in unlimited quantities and for centuries to come, without thereby perceptibly reducing the fertility of the soil on which they were produced.

It merely mitigates the evil presented to note that the soil holds large quantities of plant food still in store, that nature has provided supplies of mineral manures in concentrated form, deposited in various places, and that some investigators yet believe they will prove conclusively the assimilation by plants of the free nitrogen of the atmosphere.

Should the much disputed question of nitrogen supply be so settled, it would certainly remove a vast deal of anxiety, trouble and expense; for, as we have seen, nitrogen constitutes three-fourths in value of the plant food annually used by crops. It is surely a subject which demands exhaustive study. But the prevalence of the belief that the growing plant depends almost exclusively upon the soil and has no power to assimilate the free nitrogen of the air, is amply shown by the market prices of ammoniated manures and the extent of their sale and use.

The trade in commercial fertilizers has reached wonderful proportions, and agriculturists hail with joy the discovery of every new deposit like the potash salts of Germany and the mineral phosphates of Canada and the Carolinas. But the expense incident to mining, manipulation and transportation greatly impedes the use of these natural stores and makes the more important

every means of husbanding the home resources of every acre of arable land.

If the statement could be accepted without much qualification, we might derive great comfort from the assurance that chemical examination of soils shows the presence, within reach of the plow, of 9,000 pounds of potash and half as much phosphoric acid on every acre, or enough to supply the average crop for 225 to 250 years.[32] Now, in the first place, the average land in tillage, at the present time, by no means reaches such a standard, and, in the second place, it is well known that only a very small fraction of the plant food, actually present in the soil, is in an available form. Ordinarily, more than ninety-nine per cent of the plant food which it is possible for the chemist to find in soil, the plant itself finds dormant and unavailable. Time and natural agencies gradually convert these inert elements; but, to keep pace with agricultural demands, the physical properties of soils must be closely studied and knowledge obtained and applied regarding the proper mechanical treatment of land.

Figures already given sufficiently demonstrate the recognized condition and needs of the soil. So difficult is it to make the once fertile land bring into use the natural reserves, and so active the demand for plant food in every available form, to return to the soil that, incredible as it appears, commercial fertilizers are maintained at such selling rates as to make the entire annual farm products of this country worth almost half as much for manure, as they are in the market.[33] Do not these facts alone furnish reason enough for such a thing as agricultural science?

With our rapidly increasing population and a constantly lessening fertility of soil, we have presented to us questions of the gravest import. By the wasteful processes prevailing, we are expending our very substance and daily adding to a burden under which generations to come will stagger. The true economy of soil management, involving the production for our people of food and clothing, fuel and shelter and the wise arrangement and disposition of our surplus, are problems great enough to satisfy the ambition of both scientists and statesmen.

In an able exposition of the condition and prospects of the ag-

[32] A. A. A. S., Vol. XXXV, p. 137.

[33] Total mean value of annual agricultural products, ... $4,000,000,000.
Total value plant food in same, at commercial rates (p. 9), . . 1,980,000,000.

riculture of this country, Gen. Francis A. Walker[34] claims that the American people have been fully justified, upon sound economical principles, in the past system of cultivation of the soil, at the expense of future generations. He says: "Thirty-eight noble states, in an indissoluble union, are the justification of this policy. Their schoolhouses and factories, their roads and bridges, their railways and warehouses, are the fruits of the characteristic agriculture of the past." But the reasons for wasteful systems no longer exist. "The country in its arable parts is settled, and the line of population now rests near the base of the great sterile mountains which occupy so large a part of the continent . . . A continuance of this policy will be not the improvement of our patrimony, but the impoverishment of our posterity . . . Economical and political considerations alike demand that the soil bequeathed to this generation, or opened up by its own exertions, shall hereafter be deemed, and held, as a sacred trust for the American people through all time to come, not to be diminished or impaired for the selfish enjoyment of its immediate possessors."

These considerations should increase our regard for the business of farming and our interest in it. We should all rejoice at the revival of agricultural studies and the increasing number of able men who are making them their life's work. Let me cordially invite continued contributions to the proceedings of this section, upon foods, fabrics, forestry, industrial education and other topics closely related to our material welfare. And I appeal for more aid and encouragement for the earnest workers in other sections — in biology and chemistry, physics and mechanics—who are laboring in their various branches of science, that its practical results may be applied to economizing the fertility of the soil, which is the basis of our national prosperity.

[34] Tenth U. S. Census, Vol. III, p. xxxiii.

PAPERS READ.

PHYSIOLOGICAL AND PECUNIARY ECONOMY OF FOOD. By Prof. W. O. ATWATER, Middletown, Ct.

[ABSTRACT.]

STATISTICS are cited comparing dietaries of ordinary people with accepted standards, and the nutritive values of food materials with the pecuniary costs. It is inferred that the diet and dietary practices of American working people, as of those of other classes, might be improved:—

1. By saving food that is now wasted in large quantities.

2. By avoiding needlessly expensive food-materials and making less costly food equally palatable by proper preparation.

3. By dispensing with a portion of the fatter meats and other fatty food and using more of the leaner meats and fish.

The indications are that the benefit to both purse and health that would accrue from such improved economy would be very great.

FOOD OF WORKING MEN AND ITS RELATION TO THE WORK DONE. By Prof. W. O. ATWATER, Middletown, Conn.

[ABSTRACT.]

JUDGED from such statistics as are available (especially from dietaries collated in Massachusetts and Connecticut) the food of people in general, in this country:

1. Is large in amount.

2. Includes very large proportions of meat and other animal food-materials.

3. Is consequently very rich in protein and in potential energy.

These statements apply to the dietaries of mechanics and other manual laborers. Compared with those of people of corresponding classes in Europe, the food of Americans is much superior in each of the respects mentioned. The American does more work than the European. It is inferred that his greater efficiency is due, in part at least, to his better nourishment. Chemical and physiological considerations and detailed statistics are cited in support of this view.

THE SCIENCE OF CIVICS. By HENRY RANDALL WAITE, Ph.D., New York, N. Y.

[ABSTRACT.]

1. *The term Civics. Its meaning and its scope.*

It includes correlated facts in Ethics, Politics (Political Science) Economics and Jurisprudence, considered with reference to their bearings upon questions of vital importance in affairs of government and citizenship.

2. *The relative position of Civics among the sciences.*

(1) Its recognition as a science will be an effectual aid to the more exact definition of the limits of the separate, but related, fields in which it finds its own material; and as a result will lead to more satisfactory results in the study of Ethics, Politics, Economics and Jurisprudence, separately considered. (2) The assignment to a common field, for study and investigation, of the related facts in the several fields above referred to, will secure for them an attention commensurate with their importance.

3. *The study of Civics.*

(1) Its importance as a preparation for the discharge of civic duties, in public and private stations. (2) Some observations as to methods of study, in public schools, higher institutions, etc.

RELATIVE VALUES OF DIFFERENT KINDS OF MILK AND MILK PRODUCTS. By Prof. HENRY E. ALVORD, Amherst, Mass.

[ABSTRACT.[1]]

REFERENCE is first made to a paper entitled "Relative Values of Human Foods," by the same author, contributed to the Ann Arbor meeting and published in A. A. A. S., vol. xxxiv, p. 504. To that paper including its tables, this is a supplement. The nutrients contained in the articles named, according to their average chemical composition, are the basis of valuation, and the standard for values of the protein and carb-hydrates contained is the same as fully explained in the former paper.

With this explanation the following table is presented, compiled from sources too numerous to cite, but all believed to be authentic.

[1] This paper will appear in an extended form, in the Proceedings of the New York State Dairymen's Association for 1888.

TABLE OF VALUES OF DAIRY PRODUCTS.

DIFFERENT DAIRY PRODUCTS. (Composition and value per 100 pounds.)	Protein.	Carbo-hydrate.	Computed value as food.	Average market price.	Price greater + Price less — than value
Chemists' standard cows' milk	4.00	10.62	3.6	3.25	— a
Average all kinds " "	3.41	11.23	3.24	2.79	— b
Galloway " "	5.36	8.86	4.45	3.25	— a
Bengali " "	5.19	10.07	4.44	......	—
Devon " "	4.37	12.56	4.02	3.25	— a
Jersey " "	3.98	13.88	3.82	3.50	— c
Guernsey " "	3.97	13.63	3.81	3.50	— c
Brittany " "	3.96	10.89	3.76	......	—
Danish " "	3.90	10.69	3.56	......	—
Ayrshire " "	3.76	11.65	3.54	3.25	— a
Shorthorn " "	3.74	11.83	3.52	3.25	— a
Kerry " "	3.40	10.96	3.21	.....	......
Dexter " "	3.35	11.05	3.20	......	......
Holstein " "	3.15	9.67	2.95	3.25	+ a
Hollander " "	3.03	10.65	2.93	3.25	+ a
Fribourg " "	2.84	11.68	2.86	3.00	+ d
Dutch " "	2.78	11.42	2.80	3.00	+ d
Goat's milk	3.80	12.98	3.65	......	......
Sheep's "	7.12	14.67	6.15	......	......
Skim milk (cows)	3.06	6.15	2.63	1.77	— e
Buttermilk	3.78	5.89	3.13	1.77	— e
Condensed milk	16.07	60.06	15.77	20.00	+
Cream, average	3.70	48.51	6.06	12.50	+
Butter, average of all	0.86	146.15	10.67	25.00	+
" Jersey	1.30	152.78	11.41	30.00	+
" Ayrshire	1.40	151.81	11.42	25.00	+
" Holstein	2.65	143.55	11.82	25.00	+
Cheese, full cream, av.	27.16	55.78	23.46	15.00	—
" pure Jersey milk	28.18	64.81	24.48	15.00	—
" half skim	27.62	38.92	22.61	12.00	—
" skim milk	32.65	21.50	25.01	10.00	—
" whey	8.88	66.91	11.08	......	......

NOTES UPON THE TABLE:—*a*, rate of 7 cts. per quart.; *b*, 6 cts. per quart; *c*, 8 cts. per quart; *d*, 5 cts. per qt.; *e*, 4 cts. per qt.

The value of butter is greatly increased by containing protein which is the troublesome ingredient, hence, although that butter is best which has the least protein, the value assigned the latter makes the poorest butter stand highest in nutrient value in the table.

Excepting butter and cream, all milk and milk products generally sell in market at prices below their values as measured upon the assumed standard, and compare favorably with the other common articles of food, as given in the table first mentioned above.

An interesting feature is the difference in value, because of difference in average composition, of the milk from the various pure breeds of cows; milk as a rule sells in market with some regard to its "richness," but very little as to its origin. The table shows that the milk of certain breeds sells for less than its value, and the milk of other breeds is worth less than the usual selling price. As a single example,—the milk of Jersey cows, even when sold at eight cents per quart, is as much below its value, or in other words, is as cheap food, as average milk sold at six cents per quart.

THE TESTIMONY OF STATISTICS AS TO THE SHARE OF LABOR AND PRODUCTION. By Prof. EDMUND J. JAMES, Univ. Penn., Philadelphia, Pa.

WEALTH OF THE REPUBLIC. By CHARLES S. HILL, Washington, D. C.

ON THE RATES OF INTEREST REALIZED TO INVESTORS IN THE BONDED SECURITIES OF THE U. S. GOVERNMENT. By E. B. ELLIOTT, Washington, D. C.

THE INCREASE OF BLINDNESS IN THE UNITED STATES. By LUCIEN HOWE, M.D., Buffalo, N. Y.

METHODS AND RESULTS OF MANUAL TRAINING. By Prof. C. M. WOODWARD, Washington Univ., St. Louis, Mo.

[The substance of this paper will be included in a book to be published by D. C. Heath & Co.]

MANUAL TRAINING IN THE PUBLIC SCHOOLS, FROM AN ECONOMIC POINT OF VIEW. By Prof. E. J. JAMES, Univ. Penn., Philadelphia, Pa.

THE CHINESE QUESTION FROM THE CHINESE STANDPOINT. By YAN PHOU LEE, New Haven, Conn.

EXECUTIVE PROCEEDINGS.

REPORT OF THE GENERAL SECRETARY.

General Sessions of the Thirty-sixth Meeting of the Association held at Columbia College, New York, August 10 to 16, 1887.

Wednesday Morning, August 10.

The first General Session was held in the great hall of the library of Columbia College. President Morse took the chair at 10 a. m., and called upon Rt. Reverend Henry C. Potter, Bishop of New York, to open the session with prayer.

The prayer offered by Bishop Potter was as follows:—

Almighty and ever-living God, who art always more ready to hear than we are to pray, and who art wont to give to us more than we can desire or deserve, we come this morning to ask Thy blessing upon this assemblage, and to commend to Thy fatherly care and guidance all those who are here gathered together. We thank Thee for the revelation of Thyself which Thou hast made in nature, and for all the gifts and powers with which Thou hast crowned Thy creature, man. Thou hast taught us in Thy holy Word, "Seek and ye shall find, knock and it shall be opened to you," and as, over against the unsatisfied hunger of man for light and knowledge, Thou hast placed Thy wondrous universe with all its stores of hidden light, we bless Thee for all the rewards which Thou hast given to those who, patiently turning over the pages of the book of the created, have been privileged to read in it the laws of never-resting progress and development which Thou hast written there. Help us to welcome Thy truth, however it may come to us and in whatsoever volume it may be written. Save us from being afraid of it, but rather teach us to be confident that as Thou art Truth, so all truth is one with Thee, and give to us who are seekers after truth a larger vision of it and a more deep and enduring hunger to know it, that so, seeking in Thy fear to bring light out of darkness, and to turn ignorance into knowledge, we may each one help to hasten the day when light and knowledge shall everywhere prevail. May we love the truth for its own sake, rather than for what it can earn or win in any merely material currency, and grant that the members of this association may employ their powers for noble and unselfish ends, so lightening the toil, and sharing the burdens, and clearing the pathway of their fellowmen.

Bless, we beseech Thee, all institutions of learning which are repre-

sented here, and all others throughout the land. Give to those to whom Thou hast given the dignity and privilege of being teachers, patience, courage and wisdom. And, out of all our labors and studies here, grant that there may come, O God, the vision of Thyself that so, in Thy light we may see light, that all our children may be taught of the Lord and that great may be the peace of our children. And all this we ask in the name of Him who has taught us when we pray to say

Our Father which art in heaven, hallowed be Thy name. Thy kingdom come. Thy will be done in earth as it is in heaven. Give us this day our daily bread. And forgive us our debts as we forgive our debtors. And lead us not into temptation, but deliver us from evil: for thine is the kingdom and the power and the glory, for ever. Amen.

In a few fitting words the RETIRING PRESIDENT then resigned the chair to his successor, Professor SAMUEL P. LANGLEY. President LANGLEY spoke briefly in reply to President MORSE'S introduction, and then gave way to Rev. Dr. F. A. P. BARNARD, President of Columbia College, who, as Chairman of the Local Committee, welcomed the Association to New York as follows:

Mr. President and Members of the American Association for the Advancement of Science: It is made my pleasant duty to bid you welcome to the city of New York. This great metropolis opens wide to you her hospitable arms, and tenders freely to you all that she possesses which can awaken your interest or promote, during your sojourn with us, your comfort or your convenience. And she has much to offer which cannot fail to interest you, not only as men of science, but also as men of letters, which many of you are, or as men of taste, men of general culture or men of practical minds. She is prepared to throw open to you without reserve her vast commercial houses, her great manufacturing establishments, her extensive foundries, her noble institutions of learning, her libraries, her scientific collections, her museums of art and natural history, her banks, her exchanges, her temples of justice, her penal and charitable institutions, her menageries and her churches — everything, in short, that civilization has created at this its highest point of culmination upon the Western Continent, she submits to your critical inspection, your careful study and your intelligent appreciation.

On the other hand, her citizens will find in you not only honored and honorable guests, but subjects of a reciprocal interest and curiosity. The names of many of you are already and deservedly well known to them, but it can be said of only comparatively few that your persons and countenances are familiar. It is an entirely legitimate as well as natural curiosity which leads men to desire to look upon the features of those whose labors have done honor to our common humanity. Our citizens will, therefore, throng your assemblies with the feeling which draws men to any point where superiority of whatever kind, literary, political or scientific, is the attracting force; and they will listen to your words with interested and respectful attention if they do not always understand them.

The noble object of your organization is expressed in its title — the Ad-

vancement of Science. And during the forty years of your existence as an organized body Science has certainly made wonderful advances, to which you are entitled to say with just pride that no small proportion has been due to the successful labors of your own members. The names of many of those whom I remember as most active in our earlier meetings, but whom I sadly miss to-day, are already permanently recorded high up on the illustrious roll of those who have brightened the age in which they lived by achievements more honorable than those of the soldier, and more lastingly beneficent than even those of the philanthropic statesman. Of these, if I instance here a few, and but a few, it is not that I forget others no less worthy, but that the list is too long to permit me here to eulogize them as they deserve.

It was your first president, William C. Redfield, whose sagacity earliest detected and revealed to us the laws which govern the great storms of the Atlantic coast, and demonstrated their cyclonic character, thus stimulating that spirit of meteorological investigation which has created so many local observatories and given us at length a central and national weather bureau at Washington.

It was the large-minded Dallas Bache, grandson of Franklin, and inheritor of his grandfather's genius, who organized the splendid system of coast and topographic survey which has placed our country in the forefront of the geodetic science of the world.

It was the gifted Henry who gave us the intensity magnet which has woven over our continent a network of sensitive wires, and has enabled San Francisco to speak directly to New York and New York to London.

It was the magnificent Agassiz, whose comprehensive knowledge extended over the entire field of science, who taught us the laws of glacial movement, and from a single scale could reconstruct the entire fish that wore it and assign it its place among extinct or living species; but who, amidst all his greatness, esteemed it his highest glory to write himself simply Louis Agassiz, *teacher*.

It was the profound Peirce who, at one of your meetings, by the subtle instrument of analysis, made clear the physical constitution of the rings of Saturn.

It was the beloved Torrey whose knowledge, like that of Solomon, extended to every living plant, from the majestic cedar of Lebanon to the hyssop that grows upon the wall, and whose tireless and fruitful investigation gave us an exhaustive history of the "Flora of North America."

If time would allow me to extend these reminiscences, it would remind you that it was your Gilliss who created our National Observatory, your Davis who founded the American Nautical Ephemeris, your Mitchell who left so brilliant a mark upon American astronomy, your Watson who gathered up a score or more of eccentric celestial stragglers, the anomalous group of so-called planetoids; your Hare who began that course of electrical investigation which Faraday and Henry later carried out, who invented the calorimetor and the deflagrator, and gave us the oxy-hydrogen blowpipe, a source of heat which enabled the French chemists later to fuse

into a single gigantic ingot a mass of platinum weighing not less than a quarter of a ton.

Nor should I pass in silence the versatile Silliman, the omniscient Rogers, the astute Caswell, nor Hitchcock the palæontologist and discoverer of the giant ornithichnites of the Connecticut River sandstones, nor Lea the naturalist, nor Guyot the famous orographer, nor Chauvenet the mathematician and astronomer, nor Lawrence Smith the mineralogist, nor Wyman the biologist and physiologist, nor a host of others no less worthy, whom time forbids even to name.

All these have gone to their rest, many of them full of years, all of them full of honors. Others have risen to fill their places, no less earnest, no less capable, and destined to be no less illustrious. I do not name them because their work is not yet done; and because no blazonry of mine is necessary to exalt a fame which its own inherent force is sure to carry to the remotest limits of civilization. Many of these are present here to-day, and to them and to you all I extend, in the name of the citizens of New York, a sincere and cordial welcome.

On behalf of Columbia College permit me to add a single word. Though the National Academy of Sciences has, on several occasions, honored us by its presence here, this is the first time that it has been our privilege to receive your more comprehensive and more popular body within our halls. It is with unfeigned gratification that we offer to you all the resources at our disposal to facilitate your proceedings and to aid you in the prosecution of your objects. Our scientific collections which are quite worthy of your attention; our library which you see around you; our museums, our laboratories and our lecture halls, are at your service. If there is anything which we have overlooked by which we may be able further to contribute to your convenience, you have only to mention it and it shall receive our prompt attention. In the name of the trustees of Columbia College and of the several faculties, I extend to you a warm and heartfelt welcome.

President Langley, for the Association, in replying, observed that the speaker had overlooked one of the most honored among the past presidents of the Association, and asked leave to supply the omission with the name of Dr. Barnard himself, after which he went on to express briefly the acknowledgments of the Association to the city and to those who had done so much to make its kindness effective.

President Langley then addressed the Association as follows:

Members of the Association:—While, for the main purpose of our being here, we are all of one mind, some must remember a peculiar pleasure in their first attendance, when they came to these meetings as solitary workers in some subject for which they had met at home only indifference, and held themselves alone in, till here, with glad surprise, they met others, too, caring for what they cared for, and found among strangers a truer fellowship of spirit than their own familiar friends had afforded.

With such communities of purpose, wherever two or three among us are gathered together, it is a happy thing that we cannot remain strangers; for, doubtless, of the many here who have habitually breathed "the calm and still air of delightful studies," there are few but know by experience how hard it is for one coal to keep alight alone, and how especially good it is for the solitary workers to be brought at times into the warmth of companionship, so that, to a great many of us, it may be counted as the very chiefest good of such an assembly as ours to-day, that here each meets some one with a kindred glow, and finds that interest and sympathy from his co-worker without which the scientific life would be but too cold.

It is most fortunate, nevertheless, that our happy constitution, as a body not only of investigators in science, but of teachers and lovers of knowledge, brings those here in greatest numbers who disseminate as well as produce it, and who are skilled to recognize the value of the newly mined product when brought into this public exchange of ideas. We must admit here, too, that foolish ideas as well as wise ones are brought to this open mart, and that, in dealing with the variety of papers now presented for acceptance, it becomes almost as hard a task for us to shut out folly as to entertain wisdom; for, after all, who are we that judge, and how can we say "wisdom is in us to decide," when it is chiefly because we are ignorant that we are here? Probably the only rule is that taught by experience, that since art is long and life short, experience difficult and judgment uncertain, knowledge commonly advances best by such little steps, that one foot is not lifted till the other is securely planted on the solid ground of fact, and on the whole, then, while we agree that some rare visitors have come to us by the "high *priori* road," do not let us welcome without scrutiny all those who would walk over it into this Association's domain. At the same time, in view of our ignorance as to the real nature and causes of things, I would plead with those of you who are judges, for a large tolerance, even of what seem to be errors of speculation, *when* these are found in company with evidence of a faithful original study of facts; for we shall then have, at any rate, done our best not to turn away truth, even if she has come to us in an unfamiliar dress.

And now I can only congratulate this assembly of her followers on a meeting which opens so auspiciously, and express the hope, that whether in the new knowledge which we may take to the section-room, or find there, or in the social pleasures the gathering brings, this may fulfil its large opening promise of being a fruitful and happy season to us and to our Association.

The General Secretary announced the election by the Standing Committee of 227 new members since the adjournment of the Buffalo meeting. He also reported that the titles of nearly 200 papers had been received, several of which, being unaccompanied by abstracts, had not been referred to the sections.

After a few announcements by the Permanent Secretary, and by the

LOCAL SECRETARY, relating to details of the meeting, the Association proceeded to the election of a Vice President for Section A, in place of Mr. WM. FERREL, who was unable to be present. The election resulted in the choice of Professor J. R. EASTMAN, of Washington, who had been previously nominated by the STANDING COMMITTEE.

The Association then proceeded to the consideration of several proposed amendments to the Constitution, and the following were adopted:

1. The word Council was substituted for the words "Standing Committee" throughout the Constitution.
2. The words Secretary of the Council were substituted for the words "Assistant General Secretary" throughout the Constitution.
3. The last clause of Article 12 was struck out.
4. Article 13 was amended to read as follows:

The Secretary of the Council shall keep the records of the Council. He shall give to the Secretary of each Section the titles of papers assigned to it by the Council. He shall receive proposals for membership and bring them before the Council.

5. In Article 36 the last clause was amended to read as follows:

All money thus received shall be invested as a permanent fund, the income of which, during the life of the member, shall form a part of the general fund of the Association; but, after his death, shall be used only to assist in original research, unless otherwise directed by unanimous vote of the Council.

The proposition to amend Article 9, line 7, by substituting the word Secretaries for the words "Permanent Secretary" was rejected.

THE PERMANENT SECRETARY expressed the hope that one result of the adoption of the amendment to Article 36 would be a large increase in the number of life members.

[The Constitution as amended is printed in the first part of this volume.]

The PERMANENT SECRETARY announced that notices of the death of the following members had been received since the Buffalo meeting.

WM. ASHBURNER, San Francisco, Cal. (29). Died April 20, 1887.

DANIEL A. BASSETT, Los Angeles, Cal. (29). Born Dec. 8, 1819. Died May 26, 1887.

HERBERT A. BAYNE, Kingston, Ont., Can. (29). Died in Aug., 1886.

J. WATSON BEACH, Hartford, Conn. (23). Born Dec. 28, 1823. Died March 16, 1887.

MARGARETTA BOWLES, Columbia, Tenn. (26). Died in July, 1887.

PLINY E. CHASE, Haverford College, Pa. (18).

PATRICK CLARK, Rahway, N. J. (33). Died March 5, 1887.

FREDERICK COLE, Montreal, Can. (31). Died in 1887.

H. W. DAVENPORT, Washington, D. C. (30).

JOS. C. DELANO, New Bedford, Mass. (5). Born Jan. 9, 1796. Died Oct. 16, 1886.

JAMES BUCHANAN EADS, New York (27). Born May 23, 1820. Died March 8, 1887.

LOUIS HABEL, Northfield, Vt. (34).

B. F. HARRISON, Wallingford, Conn. (11). Died April 23, 1886.

WM. B. HAZEN, Washington, D. C. (30). Born Sept. 27, 1830. Died January 16, 1887.

JAMES A. KIRKPATRICK, Philadelphia, Pa. (7). Died June 3, 1886.

JOSEPH LIBBEY, Georgetown, D. C. (31). Died July 20, 1886.

EDW. P. LULL, Washington, D. C. (28). Born Feb. 20, 1836. Died Mar. 5, 1887.

J. S. MCLACHLAN, Montreal, Canada (31).

GEO. L. MARLER, Montreal, Canada (31).

BERNARD PERCH, Frankford, Pa. (35). Died in 1887, aged 37.

THOMAS F. ROCHESTER, Buffalo, N. Y. (35). Died May 23, 1887.

F. A. ROEDER, Cincinnati, Ohio (30).

JOEL DORMAN STEELE, Elmira, N. Y. (33). Died May 25, 1886.

H. H. STRAIGHT, Chicago, Ill. (25). Died Nov. 17, 1886.

J. R. WALKER, Bay Saint Louis, Miss. (19). Born Aug. 7, 1830. Died June 22, 1887.

CARL WARNECKE, Montreal, Canada (31). Died May 14, 1886.

HARRISON WRIGHT, Wilkesbarre, Pa. (29). Born July 15, 1850. Died Feb. 20, 1885.

EDW. L. YOUMANS, New York, N. Y. (6). Born June 3, 1821. Died Jan. 18, 1887.

The GENERAL SESSION then adjourned.

WEDNESDAY EVENING, AUGUST 10.

The second GENERAL SESSION of the Association was held in the Library Hall, Wednesday evening at 8 o'clock, President LANGLEY in the chair. The only business was the delivery of the usual annual address by the retiring President, Professor EDWARD S. MORSE [which is printed in full in this volume].

At this session a communication was received from Mr. H. F. J. Porter to the effect that the museums of the School of Mines would be thrown open to the members of the Association immediately after the adjournment of the session and every day during the meeting between the hours of 12 and 2 P. M.

TUESDAY MORNING, AUGUST 16.

The third GENERAL SESSION was held in the Library Hall, Tuesday morning at 10 o'clock, President LANGLEY in the chair.

The GENERAL SECRETARY announced from the NOMINATING COMMITTEE the following list of officers nominated for the next meeting of the Association and, in accordance with a unanimous vote of the Association, cast a single ballot for the entire list, who were thereupon declared duly elected as follows :—

PRESIDENT.

J. W. POWELL of Washington.

VICE PRESIDENTS.

A. Mathematics and Astronomy—ORMOND STONE of University of Virginia.

B. Physics—A. A. MICHELSON of Cleveland.

C. Chemistry—C. E. MUNROE of Newport.

D. Mechanical Science—CALVIN M. WOODWARD of St. Louis.

E. Geology and Geography—GEORGE H. COOK of New Brunswick.

F. Biology—C. V. RILEY of Washington.

H. Anthropology—C. C. ABBOTT of Trenton.

I. Economic Science and Statistics—C. W. SMILEY of Washington.

PERMANENT SECRETARY.

F. W. PUTNAM of Cambridge (office Salem, Mass.).

GENERAL SECRETARY.

J. C. ARTHUR of La Fayette.

SECRETARY OF THE COUNCIL.

C. LEO MEES of Athens.

SECRETARIES OF THE SECTIONS.

A. Mathematics and Astronomy—C. L. DOOLITTLE of Bethlehem.

B. Physics—A. L. KIMBALL of Baltimore.

C. Chemistry—WILLIAM L. DUDLEY of Nashville.

D. Mechanical Science—ARTHUR BEARDSLEY of Swarthmore.

E. Geology and Geography—GEORGE H. WILLIAMS of Baltimore.

F. Biology—N. L. BRITTON of New York.

H. Anthropology—FRANK BAKER of Washington.

I. Economic Science and Statistics—CHAS. S. HILL of Washington.

TREASURER.

WILLIAM LILLY of Mauch Chunk.

The recommendation of the NOMINATING COMMITTEE that the next meeting be held in Cleveland, Ohio, beginning on the fourth Wednesday of August, was approved by the Association.

The list of fellows, seventy-eight in number, that had been elected by the COUNCIL, was then read by the GENERAL SECRETARY, as follows:—

FELLOWS ELECTED.

Allen, T. F.
Babbitt, Miss Franc E.
Bailey, L. H., Jr.
Barus, Carl.
Bates, H. H.
Benjamin, Marcus.
Benjamin, Raphael.
Brace, Dewitt B.
Britton, Mrs. N. L.
Campbell, Edward D.
Chester, Frederick D.
Clayton, H. Helm.
Comstock, George C.
Crampton, Charles A.
Culin, Stewart.
Day, D. F.
Du Bois, Patterson.
Endemann, Hermann.
Fall, Delos.
Fernow, Bernhard E.
Fine, Henry B.
Firmstone, F.
Flint, A. S.
Fulton, R. B.
Geyer, Wm. E.
Gold, Theodore S.
Harris, W. T.
Hill, Chas. S.
Hirschfelder, C. A.
Holmes, Joseph A.
Hulst, G. D.
James, Edmund J.
Jastrow, Joseph.
Johnson, L. C.
Laflamme, J. C. K.
Lamborn, R. H.
Leavenworth, F. P.
Libbey, Wm., Jr.
McLeod, C. H.
Magie, Wm. F.
Meek, S. E.
Merrill, F. J. H.
Metcalf, Wm.
Moore, Robert.
Morong, T.
Newberry, Spencer B.
Norton, Thomas H.
Nuttall, Mrs. Zelia.
Osborn, H. L.
Peabody, C. H.
Pengra, Charles P.
Phillips, Henry, Jr.
Porter, T. C.
Power, Frederick B.
Prentiss, A. N.
Ricketts, P. C.
Rising, Willard B.
Rothrock, J. T.
Ryder, J. A.
Scott, Wm. B.
Scovell, M. A.
Scribner, F. L.
Sharp, Benjamin.
Shepard, James H.
Smith, Erastus G.
Smith, Theobald.
Steere, J. B.
Stockbridge, Levi.
Tamari, Kizo.
Treat, Mrs. Mary.
Vasey, Geo.
Vaughan, Victor C.
Vining, E. P.
Weston, Edward.
Whiteaves, J. F.
Williams, Benezette.
Willson, Frederick N.
Wrampelmeier, Theo. J.

The General Secretary then presented a communication from the Council respecting the reports of special committees, and action was taken as follows:—

1. *Committee on the Registration of Deaths, Births and Marriages.* This Committee had made a brief report and was continued, and J. S. Newberry of New York was added to the Committee.

2. *Committee on Stellar Magnitudes.* This Committee had presented no report to the Council, but after explanation by Professor Ormond Stone, it was voted to continue the Committee.

3. *Committee on International Scientific Congress.* This Committee had made no report and was discontinued.

4. *Committee on Indexing Chemical Literature.* The report of this Committee had been received and had been read in Section C. The Committee was continued.

5. *Committee on International Congress of Geologists.* The report of this Committee had been received and discussed in Section E. The Committee was continued.

6. *Committee on Anatomical Nomenclature.* The report of this Committee had been received and placed on file. The Committee was continued.

7. *Committee on Transportation of Specimens through the Mails.* No report had been received from this Committee and it was discontinued.

8. *Committee on Physics Teaching.* This Committee had made a report of progress and of plans for the future and it was continued.

The General Secretary then presented several resolutions that had been approved by the Council, and they were adopted by the Association as follows:—

1. *Resolution relating to the Coast and Geodetic Survey.*

Whereas, it has been generally understood that the present superintendent of the United States Coast and Geodetic Survey was only appointed to act temporarily in that capacity, and that it was the intention of the President of the United States to appoint, ultimately, to this important office some one, who, while his integrity and executive ability shall command the confidence of the Executive and of Congress, shall be qualified by his previous training in, and his familiarity with, scientific methods to direct its scientific work; therefore

Resolved, that it is respectfully urged upon the President by the Association, that his early action in making such an appointment would not only gratify scientific men, both at home and abroad, but would conduce greatly to that true economy in the administration of a scientific work, which is based upon a full comprehension of its methods and processes on the part of its superintendent.

2. *Resolution relating to the Establishment of a Bureau of Standards.*

Resolved, that in view of the rapid increase in the applications of elec-

tricity in ordinary affairs, its probable extensive use as a source of power, light, etc., in the near future, and the consequent importance of providing means for its accurate measurement, this Association respectfully urges upon Congress the importance of the establishment of a Bureau of Standards, by which accurate standards of measure shall be constructed and established not only for electricity, but for heat, light, etc., and arrangements made for the issue of authenticated copies of the same whenever possible.

3. *Resolution relating to Index of Literature of Meteorology.*

Resolved, that the American Association for the Advancement of Science recognizes the great prospective value to both practical and scientific men of the publication by the Government of the Index to the Literature of Meteorology now prepared by the Chief Signal Officer, and assures him of the hearty indorsement of any action he may take looking to this end.

4. *Resolution relating to the Preservation of Archæologic Monuments.*

Resolved, that this Association appoint a special committee consisting of Miss ALICE C. FLETCHER, and Mrs. T. STEVENSON to memorialize Congress to take the necessary steps for the preservation of archæologic monuments on the public lands of the United States.

5. *Resolution relating to Tariff on Scientific Books and Apparatus.*

Resolved, that the President of the Association appoint a committee to devise methods for obtaining from Congress a reduction of the tariff on scientific books and apparatus, with power to act.

The Committee appointed by President LANGLEY under the foregoing resolution consists of Professor E. D. COPE, Professor J. R. EASTMAN and Dr. J. S. BILLINGS.

6. *Resolution relating to Appointment of Transportation Agent.*

Resolved, that Mr. P. H. DUDLEY of New York be requested to act as an Agent of Transportation for the Association, with full power to make such arrangements as may be possible, in connection with the Local Committees of future meetings, for the transportation of members of the Association to and from the places of meeting.

7. *Resolution relating to Appointment of Agent to take Copies of Resolutions to Washington.*

Resolved, that the President of the Association have power to appoint a member, as delegate, to take to Washington and deliver to the President of the United States, and to the proper officers of Congress, copies of the resolutions relating to the Coast Survey and to the proposed Bureau of Standards (Nos. 1 and 2 above).

[President LANGLEY subsequently appointed for this service Prof. T. C. MENDENHALL of Terre Haute.]

The PERMANENT SECRETARY announced that he had received letters in relation to the desirability and feasibility of holding some future meeting in the city of San Francisco; and also that, since the action of the NOMINATING COMMITTEE in selecting Cleveland for the next place of meeting, an invitation for 1888 had reached his hands from Toronto.

After an announcement from the LOCAL COMMITTEE relating to the reception in the evening, the GENERAL SESSION adjourned.

TUESDAY EVENING, AUGUST 16.

The closing GENERAL SESSION was held Tuesday evening in the Library Hall at eight o'clock, President LANGLEY in the chair.

The PERMANENT SECRETARY read a communication from Mrs. SARA L. SAUNDERS, relative to a proposed memorial to the late Mrs. ERMINNIE A. SMITH, Secretary of Section H for the Ann Arbor Meeting.

The GENERAL SECRETARY presented the following resolution from the COUNCIL, and it was adopted.

Resolved, that the American Association for the Advancement of Science approves and endorses the movement to erect in New York City a suitable monument over the remains of J. J. AUDUBON, the ornithologist.

The GENERAL SECRETARY presented the following resolution, and it was adopted:

Resolved, that the thanks of the Association be returned by the Permanent Secretary to the Mayor of the city of Toronto, the Canadian Institute, the University of Toronto, and University College, for the invitation to hold the meeting of the Association in Toronto next year; that the Association regrets that other arrangements had been completed previous to the arrival of the invitation, and hopes that it may be able to accept the courtesies of the city of Toronto in some future year.

The GENERAL SECRETARY read the following resolution proposed by a SPECIAL COMMITTEE OF THE COUNCIL:

Resolved, that in view of the very cordial welcome which this Association has received at its first but long contemplated meeting in the city of New York, its warmest thanks are due and are hereby tendered as follows:—

To the TRUSTEES OF COLUMBIA COLLEGE for generously placing their buildings and apparatus at the service of the Association during the week of the meeting.

To Rev. Dr. F. A. P. BARNARD for promptly and cordially assuming at short notice the onerous duties of Chairman of the Local Committee, and for his able and courteous welcome to the Association at the opening session.

To the COMMITTEE APPOINTED BY THE NEW YORK ACADEMY OF SCIENCES for its tireless efforts and efficient coöperation with the Local Committee, to ensure the success of this meeting of the Association.

To Mr. H. F. J. PORTER, General Superintendent of Columbia College, for the completeness of his arrangements for the comfort and accommodation of the Association in all branches of its work.

To the TORREY BOTANICAL CLUB, to whose unceasing efforts the Association is so much indebted for the social as well as the scientific success of the meeting.

To the COLLEGE OF THE CITY OF NEW YORK for the liberal offer of the use of its buildings.

To Professor H. L. FAIRCHILD, Secretary of the Local Committee, on whom has devolved a large share of the labor of preparation and execution of the arrangements for the meeting, and to whose energy and executive ability the success of the meeting is so largely due.

To Professor D. S. MARTIN, Mr. P. H. DUDLEY, Mr. HENRY MONETT, and Mr. E. B. SOUTHWICK, for the arrangements which have resulted in such pleasant receptions, delightful excursions, and facilities for transportation, and for free use of the telegraph.

To Mrs. J. S. T. STRANAHAN and the DIRECTORS OF THE UNION FERRY Co., for the exceedingly enjoyable excursion in the harbor of New York.

To Mr. G. F. KUNZ, Mr. L. P. GRÂTACAP, and their many associates on the Local Committee for their zeal in their varied work and especially for their success in securing to the Association so large an accession of desirable members.

To the LADIES' RECEPTION COMMITTEE for their many kindly courtesies during the meeting, and especially for the reception to members and their families in the Metropolitan Opera House.

To Honorable H. G. PEARSON, Postmaster of New York, for his kindness in arranging the conveniences of a local post-office; and to Mr. G. C. VOORHEES, the assistant in charge of the local post-office, for his successful management of the duties of the position and for unfailing courtesy in his dealings with the members of the Association.

To the several RAILROAD, TELEGRAPH, and EXPRESS COMPANIES that have furnished special rates and accommodations.

In support of the foregoing resolution, Professor W. H. BREWER dwelt particularly on the favors shown by Columbia College; Professor F. W. CLARKE recognized the service rendered by the Academy of Sciences; Professor C. M. WOODWARD spoke in appropriate terms of the labors of the Local Committee; Professor W. G. FARLOW called special attention to the efficiency of the work done by the Torrey Botanical Club; Dr. JOSEPH JASTROW warmly acknowledged the efforts of the ladies that had been crowned with such brilliant success.

The resolution was adopted by an unanimous vote.

The statistics of the meeting, prepared by the PERMANENT SECRETARY, were then read.

The PERMANENT SECRETARY also gave effect to a vote that had previously been passed by the COUNCIL, by presenting, in the name of the Association, to the efficient Local Secretary, Prof. H. L. FAIRCHILD, a complete set of the volumes of Proceedings of the Association.

PRESIDENT LANGLEY followed with a few closing remarks, and the meeting adjourned.

W. H. PETTEE,
General Secretary for the
New York Meeting.

Appendix to Report of General Secretary.

Aside from the regular and formal sessions, whose proceedings are recorded on the preceding pages, the Association had opportunity to meet as a body at several receptions and excursions.

Thursday evening, the Ladies' Committee tendered a general reception to the members of the Association and their families at the Metropolitan Opera House.

Friday afternoon, a water party and reception were given by Mrs. J. S. T. Stranahan and the Directors of the Union Ferry Company. The party was taken on the ferryboat "Brooklyn" to view the Upper Bay, the United States Navy Yard, Governor's Island and the Bartholdi Statue of Liberty. The sail was extended through the Lower Bay as far as the Iron Pier at Coney Island.

For Saturday, two excursions were arranged: one by ocean steamer to Long Branch, the other up the Hudson River to West Point. On the river excursion, dinner was provided by the Local Committee at Cranston's Hotel.

Monday evening, a special meeting of the New York Academy of Sciences was held in the Library Hall, to welcome the Association. Professor J. S. Newberry presided and exhibited a collection of interesting fossils. An appeal was made by Professor D. S. Martin for aid towards erecting in New York a suitable monument over the remains of Audubon. Professor Henry Drummond of Glasgow delivered a lecture on "The Heart of Africa," giving observations on a recent scientific tour to the region of the Zambesi and Lake Tanganyika. Mr. G. F. Kunz followed with a brief paper descriptive of a remarkable collection of meteorites and polished agatized wood, which was on exhibition. At this meeting it was announced that Mr. Erastus Wiman of Staten Island had extended an invitation to the Association to visit the spectacular performance of the Fall of Babylon on Wednesday evening, and had placed in the hands of the Local Secretary two hundred tickets of admission for the use of members, After the adjournment of the Academy a collation was served in the lower rooms.

Tuesday evening, after the adjournment of the Association, there was a general reception and collation tendered by the Local Committee.

During the week of the meeting and after the final adjournment, arrangements were made for several excursions and exhibitions, to which special sections and parties of members were invited.

A lunch was provided daily in the basement of the Library building at which a variety of dishes were served at a very moderate price.

REPORT OF THE PERMANENT SECRETARY.

THE long-deferred experiment of holding a meeting of the Association in the city of New York, in the middle of August, has at last been made, and the success of the meeting has proved that the many objections raised in past years were in large part imaginary, and that the only objection to New York is common to all other cities,— the absence during the summer of a large number of citizens who would naturally take part in the arrangements for the meeting and attend the sessions. There are, however, in every large community a sufficient number of earnest men and women who are ready to do all that should be expected by a visiting association, and all that is called for by the demands of courtesy and hospitality.

That this was eminently the case in New York was at once shown by the hearty coöperation of the Local Committee of citizens that organized at short notice and was so earnestly sustained by the trustees and officers of Columbia College, by the members of the Academy of Sciences and of the Torrey Botanical Club.

The report of the General Secretary and the daily programmes must be referred to for particulars which bear witness of the successful efforts of all the sub-committees of the Local Committee, each working in its own line for the grand result which was accomplished.

That the good will of the committee followed the Association, after the excitement of the meeting was over, is made apparent by the following letter:

To WILLIAM LILLY, Treasurer of the A. A. A. S.

DEAR SIR:

I have the pleasure of paying to you the sum of three hundred and three dollars, the amount of surplus in the treasury of the New York Ladies' Committee for entertaining the American Association for the Advancement of Science after expenses were paid. This sum was unanimously voted by the Ladies Committee to the General Society.

Yours truly,

(Signed) Mrs. Sylvanus Reed, Treasurer of the Ladies' Committee.

New York, Nov. 25, 1887.

Of similar import, and showing an appreciation of the objects of the Association is the gift of three hundred dollars from four gentlemen in Pittsburgh, in response to Mr. Brashear's statement that a little outside aid would be acceptable to the Association. Such contributions as these, and similar ones which have occurred occasionally in the past, are certainly encouraging and lead to the belief that, with a little effort, the Associa-

tion could be provided with a fund from which a considerable sum could be appropriated annually in aid of original research, or to carry on special investigations by committees acting under the direction of the Association.

Since the adoption of the present constitution, a small fund has accumulated, derived from the commutation of assessments, the income of which can be used, by vote of the Council, for aiding original research. For the first time an appropriation has been made from this fund, and the income for the past two years was appropriated by vote of the Council at the recent meeting. Although the available sum was small, a beginning in the right direction has thus been made. In order to increase this fund it is urged that members who can make it convenient should commute their assessments by the payment of fifty dollars, the income of which can be used for the current expenses of the Association during the life of the member, the principal eventually to be added to the Research Fund.

The statistics relating to the New York meeting may be briefly given as follows:— During the meeting, in addition to the presidential address and reports of special committees, there were given, in the eight sections, seven addresses by vice-presidents, and two hundred and fifty papers. Of the papers, 19 were in section A, 38 in B, 42 in C, 23 in D (including four at the union meeting of D and I), 47 in E, 39 in F, 31 in H, and 11 in I.

The present volume contains the addresses of the President and Vice-presidents, four special reports (one printed under Section C), and more or less extended abstracts of one hundred and forty-six papers; while one hundred and four papers are given by title only, in most cases owing to the failure of the authors to furnish the secretaries of the sections with proper abstracts before the close of the meeting, as now required.

Seven hundred and twenty-nine members and associates were registered during the meeting from the following places:— cities of New York and Brooklyn, 211, other places in New York State, 83; Pennsylvania, 63; Washington, 54; Massachusetts, 48; New Jersey, 43; Ohio, 37; Connecticut, 32; Michigan, 17; Illinois, 17; Maryland, 12; Missouri, 10; Indiana, 9; Florida, 9; Canada, 9; Wisconsin, 8; Nebraska, 8; Tennessee, 7; Louisiana, 6; Virginia, 6; Kansas, 6; Rhode Island, 4; Kentucky, 4; Alabama, 3; North Carolina, 3; Vermont, 3; New Hampshire, Maine, Minnesota, Delaware, Mississippi and Iowa, 2 each = 12; Arkansas, Georgia, Dakota, California, France, 1 each = 5; = 729.

Three hundred and nineteen members have been elected since the Buffalo meeting; of these 271 have perfected membership, two have declined, and forty-six have not yet replied to the notifications sent to them. Two elected at Ann Arbor and six at Buffalo have perfected membership since the last report, and seventy-six old members have paid arrears, making an addition of 355 names to the list since its publication in the Buffalo volume.

Since that list was published thirty names have been transferred to the list of deceased members, 233 have been omitted for arrearages previous

to the Buffalo meeting, and 28 have resigned, making 286 names taken from the roll published in the Buffalo volume.

Of the 1956 members now on the roll, 154 are in arrears for the Buffalo and New York assessments. Twenty-three members have become life members during the past year. Fifty-five members have been transferred to the list of fellows during the year.

The number of members and fellows given on the roll published in the Buffalo volume is 1886, and in the present volume, 1956, an increase of 70, divided as follows:

	Buffalo vol.	New York vol.
Patrons	3	3
Members	1253	1285
Honorary Fellow	1	1
Fellows	629	667
Total,	1886	1956

The cash account of the Permanent Secretary, as printed on the following pages, begins just prior to the Buffalo meeting, and closes prior to the New York meeting, or from Aug. 7, 1886 to Aug. 1, 1887. It will be noticed that the cost of the 2500 copies of the Buffalo volume was kept within the $2500 authorized, and that not only were all the expenses of the year met by the receipts, but that nearly $400 were paid on the debt to the Permanent Secretary.

The Funds of the Association are as follows:

Research Fund.

Aug. 1, 1887. Principal and interest to date,		$3,467.81
By vote of the Council at the New York meeting there have been paid from this amount:		
To Professors Michelson and Morley to aid them in the establishment of a standard of length,	$175.00	
To Dr. C. S. Minot for illustrations of papers on the development of the human placenta and on the supra-renal capsules,	125.00	$300.00
Present amount of fund,		$3,167.82

The income of this sum can be appropriated by the Council to aid in original research.

General Fund.

Aug. 1, 1887. Principal and interest to date, . . . $107.81

This fund can be expended for any purpose by vote of the Council.

F. W. Putnam,

Permanent Secretary.

Salem, Mass., Mar. 8, 1888.

F. W. PUTNAM, PERMANENT SECRETARY,

Dr. THE AMERICAN ASSOCIATION FOR

1886–7.		
To admission fees Buffalo Meeting	$ 550 00	
" " previous to Buffalo Meeting	5 00	
" " New York Meeting . . .	35 00	
Fellowship fees	118 00	$708 00
Assessments previous to Buffalo	1,182 00	
" for Buffalo Meeting	2,934 00	
" " New York Meeting . . .	687 00	
" Associates, Buffalo	177 00	4,980 00
Publications sold	94 87	
Received for binding	50 75	
" " 200 copies of Address Vice President, Sec. H.	13 35	
Postage and express refunded	9 39	168 36
Gift of Gen. Wm. Lilly	100 00	
" " Mrs. Esther Herman	100 00	
" " Dr. J. E. Chapin	100 00	
" " Mr. Chas. H. Rockwell	50 00	
" " Miss Helen C. D. S. Abbott . . .	15 00	
" " Rev. Raphael Benjamin	10 00	
" " Two members, $10 each	20 00	395 00
Life membership commutations		250 00
Balance due Permanent Secretary, to next acct.		2,751 45
		$9,252 81

I have examined the above account and it

SALEM, MASS., AUGUST 3, 1887.

IN ACCOUNT WITH

THE ADVANCEMENT OF SCIENCE. Cr.

		1886–7.
By 2500 copies Proceedings Vol. 35 (486 pages)		
Composition and authors' changes . . .	$ 920 40	
Boxes for 100 ster. plates	8 00	
Illustrations	2 50	
Paper and press-work	1,029 15	
Printing paper covers & binding 2400 copies	264 00	$2,219 05
Binding 25 copies Vol. 35, one-half morocco	25 00	
" 75 " " " cloth	37 50	
Cloth covers, 25	5 00	
Printing wrappers and wrapping 2500 vols.	28 75	
2200 extra copies of eleven addresses and reports	126 13	
Additional extras for author (Refunded)	13 35	235 73
600 copies Constitution, List of Members, etc.	120 00	
Expenses of Buffalo Meeting	331 34	451 34
Express, including distribution of Vols. 34 and 35	706 87	
Postage, Box rent, Postal Guide	234 68	
Cable, Telegraph and Telephone	8 21	949 76
Proceedings bought		9 50
Printing circulars, blanks, tickets, cards, etc.	92 80	
Petty expenses, including stationery and record book	27 37	
Extra labor	13 50	
Boxes for publications	11 50	
Rent of office	108 00	253 17
Salary of Assistant Secretary	500 00	
" " Permanent "	1,250 00	1,750 00
To Life Membership Fund		250 00
Balance due Permanent Secretary 1885–6 acct.		3,134 26
		$9,252 81

is correctly cast and properly vouched.

H. WHEATLAND, *Auditor.*

INDEX.

DATE DUE

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